MODERN PLASTICS

CATALOG • OCTOBER 1938 • DIRECTORY

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FOREWORD

THROUGH THE GENEROUS COOPERATION OF THOSE AUTHORITIES IN the plastics field who have written these informative articles, we are enabled again to present a relatively complete and detailed report of the progress made in all major branches of the plastics industry during the past twelve months.

This year, for the first time, we have invited authorities from other lands to contribute brief reports of the progress made in their respective countries. These, together with a report by Dr. Vergil D. Reed, of the U. S. Bureau of Census, present an unequalled international picture of the status of this rapidly growing industry.

The division of the book into six sections, each conveniently indexed on a separate title page, makes it possible to obtain complete information regarding materials, methods, equipment, and sources of supply by referring to that section in which the subject of interest is treated. This can be quickly determined by reference to the Table of Contents on pages 3 and 4.

The Plastics Properties Chart, which appears opposite page 172, has been revised and approved by engineers and chemists of nearly fifty companies manufacturing the materials. While it may never reach that state of perfection we would like to achieve, it is still the most complete assemblage of comparative information ever attempted for those who use plastics or plan to use them in any way.

The Directory of Trade Names (pages 297 and 298), together with names and addresses of manufacturers of the materials, has been completely revised to include primarily those materials referred to in the Plastics Properties Chart, and which are available in the current market in the United States, supplemented to a limited extent by miscellaneous trade names of related products. The Buyers' Directory (pages 285 to 304) lists all manufacturers of materials, supplies, equipment, molders and mold makers, together with testing laboratories and industrial designers. They are grouped alphabetically under various headings and their addresses will be found on pages 299 to 302.

In presenting this third annual HANDBOOK, CATALOG AND DIRECTORY number of our monthly journal, which has become the standard manual of reference throughout the industry, we express our sincere gratitude to those who have given so generously and unselfishly of their experience and time. A complete list of these contributors, together with their affiliations, appears on page 14. Without their cooperation, this presentation would not be possible.

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NOVEMBER

Winners in Modern Plastics' Third Annual Competition will be pictured and described in our November issue and all entries will be exhibited in our new offices on the 26th floor of the Chanin Building, 122 East 42nd St., New York City, after we move about November fifth. Winners this year will be recorded in an educational film with sound now in preparation which will be available without cost to organizations, clubs and colleges about November fifteenth.

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ABREAST WITH CURRENT TRENDS

by A. S. HARRISON

AUSTRALIA IS A COUNTRY WITH AN ENTIRE population of less than that of the city of New York, and yet in that country there is much plastic molding being done. It is concentrated practically in two cities, viz., Sydney and Melbourne.

The industry started in quite a small way many years ago, and has gradually grown until now Australia produces the majority of moldings used in that country. Like many industries that can be started on a comparatively small capital, there were many presses put in by people with insufficient financial backing to go ahead; however, some were the beginnings of now flourishing plastic companies.

There are the custom molders, whose entire business is built on contracts with many and varying firms for their molding work, and concerns who have a small section of their plant allocated to the production of plastic moldings, which although being an integral part of their finished unit, are but a very small proportion of it.

A few years ago the only plastic radio cabinets in Australia were show specimens imported from overseas; today they are a practical accomplishment, and many thousands of table models are being produced in a variety of shapes and designs. One radio plant, in addition to producing its own molded cases, also manufactures radio valves in a setting of lawns and gardens, tennis courts and playing areas, that would do credit to the most up to date and thoroughly American organization.

A number of five and ten cent lines are made here, and big figures are done in this business. Picnic ware from its beginnings always had a good sale. Somehow the climate of Australia is very conducive to outdoor picnicking all the year round, and this fact has been seized upon by the manufacturers with a result that there are now a number of shapes and designs of plastic ware from which to choose the picnicking set.

Domestic electrical accessories wholly designed in Australia have captured practically the entire market. The standard of the accessories is very high, and warrants the continued support this section of the industry is receiving. There was at one time a flooding of the market with Japanese and German goods, but this has now been checked by the Australian lines. Some very fine manufacturing methods have been developed for producing these articles on an economical basis.

Bottle closures are produced on mass production lines, competition being so keen that in a number of cases ruling Australian prices are lower than ruling overseas prices for a similar article in the country of production. Many of the closures are the flat-topped multi-sided type, but a number are more intricate and finely wrought, giving the appearance of hand-made pieces.

It is part of the Commonwealth Government's trade policy to encourage Australian manufacturing, and so a very large proportion of the telephones used are of domestic manufacture. The Postmaster General's Department owns all the telephones, and hires them to subscribers at an annual rental, consequently they are the only purchasers of telephones for the network connecting Australia. Telephones are produced in several factories, and the great accuracy that the Telephone Department calls for is rigidly adhered to. Similarly, the Local Governments give a preference to Australian made articles, with a result that electricity meter cases are now being produced here from plastics.

There is quite a big range of industrial parts as well as innumerable novelties, produced by many companies. Artistic lampware in attractive variety has been produced in plastics. Random items of production are standard size chessmen, table tops, cosmetic containers, jelly molds, cigaret boxes, toilet seats, wool-holders, ring cases, etc., etc. Plastics are decorated with intaglio and embossed designs and lettering, molded in two colors and color filled, as well as color filled only. Two color drinking vessels, such as scarlet outside and white inside, were done as early as 1924.

The powders are mainly phenolic or urea type, and are practically all imported, there being only a small production of powder in Australia. Very interesting work has been done with injection, particularly in automotive hardware. Metal handles and fittings have been encased in acetate. A small amount of cast resin is being turned to jewelry and fashion items.

The industry is thriving, and special praise is due molders for producing so many lines economically for the relatively small market available. Much of the plant is fabricated in Australia, most firms having their own tool shop, and being their own designers and engineers.

The presses are quite up to date, most being built on the best American and English lines. These are tilting head, fully automatic, angle, and downstroking of large dimensions, up to 1000 tons, all working regularly. Hobbing is being done with 2000 ton presses, and jobs up to 6 in. diameter are being handled with ease.

The geographical position of Australia makes for ingenuity, in that where a special (*Please turn to page 13*)

ENGLAND

MATERIALS, METHODS, MOLDINGS

by G. NORMAN HIGGS

MANUFACTURING CONDITIONS IN THIS OLD country are somewhat different from those in the United States and it is mainly on this account that we find when visiting either territory that America is very much ahead on certain details and on others it is vice versa.

There have been no very striking departures in England during the past twelve months, although steady general progress has been made. The English plastic manufacturer, has, on the average, to deal with much smaller quantities and it is this particular point that is responsible for much of the variation in our respective production methods.

America has been ahead in machine tool design for many years, and although perhaps machines of English manufacture have been just as satisfactory in operation on low quantity production, they have not been produced with the pleasing lines of design found on both American and German machine tools. We have improved considerably in this respect during the past few years, but as an illustration, where a carefully designed bracket is fitted to a machine of American manufacture, some of the old English concerns are still content with a piece of black angle iron and a few black bolts.

Progress has been made on materials. The manufacture of styrene resins has been commenced; previously we relied on our supply of this material from Germany. A mixture of vinyl chloride and vinyl acetate has been placed on the market which appears to be quite satisfactory for injection molding and should soon be in strong demand. The quality and workability of aminoplastics have been greatly improved and a fully transparent material has been produced which was later improved with regard to ease of molding and ejection, shrinkage and water absorption. Attractive transparent colors as well as a good reproduction of tortoise-shell are obtainable with this material. Another new product and, I believe, the first shock-resisting urea material to be placed on the market, has an impact strength of approximately double the ordinary grade, and combines the claimed non-tracking characteristics of urea-formaldehyde, fulfilling many of the special requirements of the electrical trade. A new liquid glue prepared from urea resin is not self setting, but requires the addition of a hardener or catalyst which promotes a chemical reaction in the resin and sets the glue to a jelly, which soon hardens to give a strong and permanent joint. This particular glue is in use for the manufacture of plywood and the construction of speed boats, seaplanes, aeroplanes, etc., and has the approval of our British A.I.D. A further introduction is a urea resin which is stated to have great water resistance, better gloss, greater compatibility with alkyd resins and nitrocellulose, and greater miscibility with hydrocarbons.

Improvements in our phenol-formaldehyde material are much on a par with those reported from your country, and greater use is being made of metallic fillers than previously. Thin laminations of wood bonded with resin are showing some interesting results.

Little change appears to have been made in either design or the operation of our compression presses. The standard prefilling semi-automatic down-stroke press is undoubtedly the most popular, but there is certainly an inclination towards self-contained units in place of one pump and accumulator for the power supply of a number of presses. One fitting which I think is worthy of mention and will fulfill a much needed requirement where down-stroke presses are in use is claimed to prevent the closing down of a press on account of valve leakage, etc., when it should be kept open. And to those who have had experience in the operating of this type of press, this safety device should be of great value.

I fear that the less said the better as regards injection machines produced in this country. At present we are depending entirely upon those manufactured in Germany and America in the way of the fully automatic type.

Little has been mentioned about extrusion molding in America and I am inclined to think that we are perhaps a little ahead in this respect although the original idea appears to have emanated from Germany. Tubes, rods and lengths of special sections are being extruded in fairly large quantities. Stencil rollers 5 in. in diameter, of thin section are being extruded in lengths from 8 to 12 ft. being cut off to the desired length after molding. Extruded transparent drinking "straws" are used in well known restaurants.

Moldings of particular interest are: fans with $12^1/_4$ in. diameter which extract 22,000 cu. ft. per minute, tables with collapsible legs, bath racks, steering wheels, cellulose acetate chimneys for hurricane lamps, electric heater housings and railway ticket files.

A decided improvement has been made in the manufacture of plastic optical lenses by the introduction of a new process of surface hardening which is stated to withstand all normal usage. Another new departure is the reproduction of photographs in cellulose acetate by a special embossing process, (*Please turn to page 13*)

FURNITURE AND DECORATION ADVANCE

by CHARLES M. CHAMBERS

PLASTIC PROGRESS IN FRANCE DURING THE past year has been toward wider variety of materials, application to larger objects including furniture, more automatic operations in both production and finishing and production of new formulas. One important development has been the manufacture of polystyrene molding powder.

In production there has been improvement in automatic operation. But most of the new machinery is of German origin. Not only is automatic molding being increased, but finishing operations are now automatic at many plants and this even applies to adoption of tumbler polishing of products. Technically, there have been no important changes in compression molding, but many new injection molding machines are in use mostly imported from Germany.

The trend toward larger moldings has been marked, and the largest ever made in France (believed here to be the largest ever made) is pointed to with considerable pride. It is a rectangular table top with an area of 930 sq. in. (24 by 40 in.) (See MODERN PLASTICS, July 1938). It is of urea molding powder and was produced on a 1500-ton press. Principally a manufacturer of electro-technical parts, this molder has been following current trends in the plastic field and expanding its production to include a wide variety of products, materials and colors. The company employs about 1000 and has 350 hydraulic presses ranging in capacities from 10 to 1500 tons. It makes most of its own molding powders, which include bituminous, natural resins, phenolics, urea, cellulose and vinyl resins. The basic business of this company, however, continues to be battery boxes for every use from miners' lamps to huge submarine battery jars. One of the new products added to the line, though, is a complete plastic camera.

Manufacture of furniture of various kinds, and large switchboards is being done by several firms specializing in the laminating branch of the industry. One concern has expanded its work from technical products to consumer goods. In particular it has extended application of laminated materials into furniture and for use in decorative panels. Its principal products are a canvas base material impregnated with phenolic; a paper base impregnated with resin and a cellulose in sheets, impregnated with aminoplast (urea). In the past couple of years, this company has supplied a growing demand for insulating material with good mechanical qualities coming from the electrical and radio manufacturing fields. Most of this was made from the canvas based phenolic impregnated material which gives it greater tensile strength and impact resistance.

Greatest growth in use of plastics, however, and the one promising most for the future is in furniture and interior decoration. Some French producers have specialized in laminated furniture, and employ a large staff of artists, designers and engravers who work on design specifications furnished to them or create original work. Much of this is for paneling in theaters, motion picture houses, hotels, ships and other public places. Decorators, though, like this plastic paneling so well, that there is prospect of an increasing amount being specified for use in finer private homes.

Some of the finest decorative panel work of one company appeared at the Paris Exposition last year in the form of six large panels. Two of these were 6 by 9 ft. and four were 6-feet square. All were painted in by hand, the plastic being embodied in the material, on which it is laminated so that it is undamaged by rubbing or water. Shades and tones are similar to finely painted chinaware. But color variety on china is restricted by necessity for firing up to 1200 deg. F. In the panels where colors of plastics are fired at 275 deg. F., an almost unlimited range is permitted so that almost every shade used in ordinary water colors is obtainable in such panels. Those shown at the Paris Exposition were not a special experiment for show purposes except in their size, which was somewhat larger than customary. Interior designers here are enthusiastic over the possibilities of this paneling in all kinds of decorative work. Furthermore, they are increasingly specifying plastic chairs, tables, beds and other furniture both for inside and out-of-door furniture. Meanwhile, efforts are being made to secure approval for substitution of plastics in school desks, instead of the traditional wood.

A large telephone switchboard with positions for twenty operators has been produced which uses laminated in a plain light cream shade. This is made of cellulose sheets impregnated with aminoplast (urea). The tops of the switchboard units are of 3 mm. cream laminated glued to plywood. Sides are 1 mm. thick. Edges and semi-circular pieces are molded. Use of paint or special finish has, of course, been permanently eliminated. This departure in the manufacture of industrial equipment illustrates, perhaps better than anything else, the trend toward a greater appreciation in this country of the decorative and lasting surfaces made available by plastics.

ECONOMICS ACCELERATE DEVELOPMENTS

by ALEXANDER BALL

A REALLY IMPORTANT FORWARD STEP MADE by the German plastics industry during the past twelve months is an attempt at standardizing synthetic resins undertaken by a cooperative action of the makers and users of plastics in conjunction with the State Material-Testing Office. A clear survey of the whole field has been made possible thereby, a survey showing that, while new applications for plastics are being found day by day, in other lines one plastic is already replacing another which may be less suitable or imported.

Cellulose plastics, the venerable ancestors of our quickly growing family, are still going strong in Germany, but are largely substituted by polymers in cases where foreign exchange may be saved by using polymerization resins of German origin instead of cellulose, which has to be imported into the country. The annual production of cellulose plastics in Germany may be estimated at 20,000 tons, 50 percent being produced from cellulose nitrate, 9 percent from cellulose acetate and the rest being fiber and other cellulose products. The German cellulose plastics industry exported from 30 to 50 percent of their products in the past twelve months, and within the German frontiers it has opened new fields by substituting ivory and ivory-nut, mother of pearl, horn and tortoise-shell. Cellulose plastics also account for a large percentage of the 650 million ft. of artificial gut for sausages annually used. On the other hand, styrene resins are increasingly employed for the injection molding of combs, and drawing instruments and gages. Aircraft windows are now also being made of polymers.

An interesting new technique has been devised and now brought to commercial use here in making soap boxes, pill boxes and unbreakable glasses from cellulose acetates derived as by-products of rayon production. The cellulose acetate is dissolved in a plasticizer, and molds are dipped into the solution. When the plasticizer has evaporated, the cellulose plastic product can be taken off the mold. It is seamless, not easily inflammable, melts at 250 deg. C. (482 deg. F.), resists water, light and not too concentrated acids, and it can be made transparent as well as colored.

In view of the Four-Year-Plan aim to save foreign exchange wherever possible, any extension of plastics made of casein or shellac is not thought opportune, so little progress has to be recorded in this field. Shellac is still being largely used in the production of gramophone records, owing to its comparatively low price, but it is stated here that various polymerization resins have proved to be technically equivalent and phonetically even superior to shellac as a (basic) material for records.

Phenolic resins have apparently the most promising future of all plastics in Germany, as they are not only derived from raw materials obtainable within the German frontiers, but have also qualities surpassing those of many a non-ferrous metal. In three directions rapid strides have recently been made here in employing laminated or molded phenolics: (1) in the manufacture of bearings for rolling mills, lorries, cranes, etc.; (2) in aircraft design; (3) in automobile body production.

The replacement of bronze by laminated phenolic resin in the bearings of rolling mills has been going on here for some years, but has been completed in several groups of such bearings only by the beginning of 1938. The former annual bronze consumption of 3400 tons had been reduced by 47 percent to 1800 tons in 1937 and will be further reduced by 75 percent to about 850 tons in the current year. Sufficient cotton fabric has been set aside, together with phenolic resin, for forming the material of which the bearings are made. In the future, cotton cloth will also be replaced by viscose fabric.

In aircraft design, laminated phenolics of the standardized types T 3 and Z 3 (sheets of fabric and of paper, respectively, impregnated by phenolic resin) are being used—partly experimentally as yet—for propeller hubs, ribs and walls. Moldings are so far not employed for mechanically stressed 'plane parts, but to a large measure for handles, levers and lever balls, instrument panels and the like. Wood sheets are glued together by urea resins, and fuel pipes of vinyl polymers are being tested.

Plastic automobile roofs, doors and side walls formed a center of attraction at the 1938 International Motor Show held in Berlin in March last. These parts were designed by the Auto-Union, one of the biggest German automobile concerns, and produced by the Dynamit Nobel A.-G. of Troisdorf, a plastic material supplier and molder, by means of a 5000-ton press made by Becker & van Hüllen, of Krefeld—a fine example of cooperation in the plastics industry. Tests with plastic car bodies, though not finished as yet, have already shown that these bodies are better than all-metal bodies in that they are almost noiseless and are considerably lighter. Several hundreds of cars with all-plastic bodies will be completed in 1938 and subjected to severe tests, from the results of which it may depend whether or not the forthcoming 400-Dollar-Car to be produced at Fallersleben will be equipped at least with roofs (*Please turn to page 13*)

SYNTHETIC PHENOL EXPANDS INDUSTRY

by ADOLFO OTTOLENGHI VITERBI

THE MOST IMPORTANT FACT WHICH APPEARS upon examination of the development of the Italian plastics industry during 1937 is the increase of 70 percent in phenolic resins consumption and that of 100 percent in urea resins consumption. The manufacture on a commercial scale of phenol-formaldehyde resins was started in Italy in 1923, but during the first years this branch had an irregular development. Only recently has its activity begun to move on a more definite and solid line after the question regarding raw materials was successfully and adequately answered.

The preparation of formaldehyde was actually performed since 1923 in connection with important plants for the manufacture of synthetic methyl alcohol. The supply of phenol, was not so certain owing to the rather limited availability of tar. Today, it may however be considered as satisfactory, a large plant working since 1935 for the preparation of synthetic phenol from benzol and two big coke works having been erected recently, which provide the Italian market with large quantities of tar. Furthermore a first plant for the manufacture of synthetic urea was started during 1936, so that the supply of this raw material does not cause any apprehension.

At the same time that raw materials were being developed, the resins and molding powder industry was consolidated, while simultaneously an extensive publicity campaign was undertaken with regard to the various applications. The industry has therefore found favorable conditions for its expansion, which started in 1937 and is now in full development.

The most important consumer of molded phenolic products is still the electrical industry, but they are also receiving rapid acceptance in other industries. Particularly extensive progress was noted during 1937 in the use of telephone apparatus made entirely of molded material, as well as in the production of broadcast apparatus with molded casing. A further important success was the nearly complete substitution of molded phenolic parts for stainless steel parts for machines of the rayon industry. The most interesting novelty of 1938 is the preparation of complete furniture of molded parts for the equipment of the State Railway cars, comprising: a little hinged table weighing about 3 kg., a toilet seat and seat cover, a box for towels, lustres, labels, decorative frames hitherto made of wood, etc. Within the current year the Railway Authorities will be supplied with the parts required for the equipment of 500 new cars, while at the same time negotiations are already being made for further supplies. The molding of urea-formaldehyde resin for the front wall of domestic refrigerators will also be completed this year: this will be the largest part which has been molded up till now in Italy (about 1 m^2) and will require a press of 4000 tons, which is being assembled at the present time.

Great activity is noted in press building: up to 1937 the most capable presses existing in Italy consisted only of a few machines of 1000 tons; today the 1000-ton presses are largely used; others of 2000 tons capacity have been installed, and another of 4000 tons is in the course of development, as mentioned above.

The injection molding of thermoplastic resins is still at the initial state, but good results have already been obtained by using ordinary presses suitably adjusted; of particular interest are big carters of phenolic resins for the rayon industry, which it was found suitable to mold by injection in view of the fact that the very thick piece would require too long a time for compression molding.

The Italian production of laminated plastics is still comparatively moderate; however, in this field too, progress is being made and their use has also extended outside the electrical field. It may be mentioned, for instance, that gasoline tanks of $^1/_2$ m^3, a great number of which was supplied during 1937 to Aeronautics and Marine Authorities were made wholly of laminated material, of high mechanical resistance and also resistant to the corrosive action of gasoline.

Casein has shown some progress during 1937; however if it has lost some applications which have been substituted by more modern plastics, it still maintains, on the other hand, prevalence in the button and fashion articles sections and has met with success in sliding fasteners of different colors. A new technique was adopted last year for casein in molding small sized articles directly in the forms desired.

Pyroxylin, too, has not shown during 1937–1938 a progress which might be compared with that attained by other resins, but its consumption has again noted a net increase, especially in the field of spectacles, in harmonica manufacture, largely consumed in Italy, and in the manufacture of sliding fasteners, which are all novelties with prospects of a large development.

The manufacture of two new types of plastic materials has been introduced in Italy during 1937: acetate and acrylic resins. Cellulose acetate plastic materials had no large development in Italy because of their foreign origin. During 1937 an important Italian (*Please turn to page 13*)

UNITED · STATES

STATISTICS RECORD GROWTH

by VERGIL D. REED

THE BUREAU OF THE CENSUS, AS THE OFFICIAL record keeper of the Nation's economic activities, has compiled statistics on the physical volume of the output and value of products of plastics since the beginning of the industry's development in the United States.

As an industry, plastics are difficult to pigeonhole in a classification of exact nicety. They originate from materials too numerous to mention. They are used throughout the length and breadth of American industries, wherever research and ingenuity have found new applications of sufficient importance to justify promotion and development on a commercial scale. Plastics constitute a distinct industry primarily as a technological process creating synthetic moldable substances that are light in weight, possess insulation properties, and are inert to acids and alkalies.

The plastics industry began in the United States in 1869 with the production of celluloid by Hyatt Brothers in Albany, New York. The U. S. Census of Manufactures in 1880 reported eight establishments producing $1,261,540 of plastics and of fabricated plastic products.

Statistics from the U. S. Census of Manufactures record the production of plastics in their crude or primary form in the chemical industry and, additionally, fabricated plastic products which are used in radios, automobiles, paints and varnishes, rayon, and many other industries. The quantity and value of fabricated plastic products are difficult to segregate accurately, due to their uses as parts and accessory articles in many industries, but the total value amounts to several hundred millions of dollars annually, as will be later indicated.

Table 1 shows the steady expansion in the production of plastics by the chemical industry, which reported a value of products of $38,917,266 in 1935. Production in pounds was reported as 114,413,762 in 1935. The true growth of the industry has been even more rapid than indicated by these figures because Census statistics for the earlier years from 1880 to 1909 included data on fabricated plastic products, whereas figures for later years represent only plastics in their crude form manufactured in the chemical industry.

The figures in Table 1 record the status of the principal types of plastics in their primary form. Nitrocellulose and cellulose acetate are produced from wood pulp and cotton. Coal-tar resins and other plastics embrace the synthetic resins. Natural plastics, such as rubber, rosin, and shellac, are not included. Comparable data on production of nitrocellulose or pyroxylin plastics are shown over a long period. Marked increases occurred in the production of cellulose acetate from 2,874,819 pounds in 1933 to 10,395,290 pounds in 1935, and in the production of coal-tar resins from 41,566,515 pounds in 1933 to 87,718,953 pounds in 1935. Phenol and cresol resins constituted the largest single type of plastics reported to the Census of Manufactures in 1935, amounting to 52,326,946 pounds, valued at $9,929,904. Although Census figures on phenol and cresol resins are not available as separate data prior to 1935, statistics from the U. S. Tariff Commission[1] as early as 1920 showed production of 4,659,680 pounds of synthetic phenolic resins, valued at $3,410,179. While production of phenol and cresol resins gained more than tenfold between 1920 and 1935, the average price declined from 73 cents to 19 cents per pound.

The Census Bureau collects monthly production figures on cellulose and on several types of fabricated plastic products, which provide information subsequent to the 1935 Biennial Census. Table 2 shows annual production data in 1935, 1936, and 1937 for nitrocellulose, cellulose acetate, pyroxylin spread on textile bases, plastic paints, and lacquers. Expanding output in each of these products occurred between 1935 and 1937, while declines were experienced during the first few months of 1938.

This upward trend in production of plastics reveals only one aspect of its growth, the other phase being the fanlike horizontal spread of the uses of plastics reflected in the figures of a wide range of industries in the 1935 Census of Manufactures. The impressive multiplicity of products to which plastics contribute an essential part is shown in Table 3. Even this array representing several hundred million dollars worth of fabricated plastic products is incomplete, owing to the classification of products used on Census schedules. For example, it is a well-known fact that plastics are used in considerable quantities in telephones and radios, but the 1935 Census of Manufactures does not reveal separate data for plastic products incorporated in these major articles. Similarly, plastics are used in automobiles for steering wheels, horn buttons, gear-shift balls, etc.; in electrical sockets and switches; for grocers' scales; for airplane fabrics and propellers. The Census of Manufactures does not record separate statistics on the quantity and value of plastics fabricated into these products.

[1] Tariff Information Series No. 31, Census of Dyes and Other Synthetic Organic Chemicals, 1922.

TABLE 1. PRODUCTION OF PLASTICS IN THE CHEMICAL INDUSTRY, 1880 TO 1935

		Nitrocellulose			Coal-Tar Resins[1]		Cellulose Acetate		Other Plastics
		Made and consumed in same plant	Produced for sale						
	Total Value	Pounds	Pounds	Value	Pounds	Value	Pounds	Value	Value
1935	$38,917,266	2,958,859	13,340,660	$10,682,358	87,718,953	$15,672,401	10,395,290	$7,986,489	$4,576,018
1933	19,884,426	2,849,523	10,096,033	7,799,283	41,556,515	7,508,587	2,874,819	2,245,543	2,331,013
1931	21,211,466	3,001,330	12,008,439	11,113,618	33,818,000	7,282,000			[2]2,815,848
1929	29,212,212	4,856,625	16,990,802	17,266,323					[3]11,945,889
1927	21,401,510	3,205,687	16,298,023	14,409,668					6,991,842
1925	23,590,814	4,156,313	13,703,156	13,720,802					9,870,012
1923	27,402,110	3,671,794	23,980,116	17,682,049					9,720,061
1921	13,966,108		21,678,285	13,966,108					(4)
1919	24,666,175		33,914,377	24,666,175					(4)
1914	12,654,883			12,654,883					(4)
1909[5]	7,472,732			[5]5,682,379					[5]1,790,353
1904	3,949,124			2,136,976					1,812,148
1899	3,191,330			1,526,572					1,664,758
1890	2,575,736								
1880	1,261,540								

[1] The 1935 Census of Manufactures subdivided coal-tar resins, showing separate statistics as follows:

	Pounds	*Value*
Phenol and cresol.........	52,326,946	$9,929,904
Phthalic anhydride.......	17,900,745	2,946,897
Other coal-tar resins......	17,491,262	2,795,600

[2] Includes data for cellulose acetate in 1931 and previous years.
[3] Includes data for coal-tar resins in 1929 and previous years.
[4] Data not shown separately, as figures were combined with Rayon and Allied Products.
[5] Includes data for fabricated plastic products in 1909 and previous Census years.

Source: U. S. Census of Manufactures.

TABLE 2. CURRENT PRODUCTION SERIES ON SOME PRINCIPAL PLASTIC PRODUCTS, 1935–1938

	Jan.–May 1938	Jan.–May 1937	1937	1936	1935
Nitrocellulose:[a]					
Pounds..............................	3,434,084	8,804,004	17,722,309	16,934,850	16,205,413
Cellulose acetate:[a]					
Pounds..............................	1,357,457	6,324,997	13,235,062	13,036,497	10,504,003
Pyroxylin spread on textile base:[b]					
Pounds..............................	20,964,229	32,977,202	65,786,928	62,163,474	51,564,405
Plastic Paint:[c]					
Pounds..............................	2,701,042	3,004,053	6,646,615	6,397,855	4,982,156
Value..............................	$200,149	$219,081	$519,273	$513,882	$352,371
Lacquer:[d]					
Gallons[1]............................	7,934,838	11,404,989	46,817,113	44,287,268	36,497,411
Value[1]..............................	$9,860,662	$14,347,417	$58,490,192	$55,849,980	$46,525,644

[1] Data on Lacquer represent sales. The figures in the first and second columns refer to the first quarter of 1938 and of 1937, respectively.

Source: U. S. Bureau of the Census, Current nquiries—[a] Cellulose Plastic Products. [b] Pyroxylin-Coated Textiles. [c] Plastic Paints, Cold-Water Paints and Calcimines. [d] Sales of Lacquer.

(*Please turn to next page*)

The amount of synthetic resin and other plastic products reported by 153 establishments in 1935 totalled $50,298,937 in value of products, an increase of 95.5 percent over 1933. Complete figures are not available from the 1937 Biennial Census of Manufactures at the time of the preparation of this article. However, a partial tabulation based upon reports of 101 identical manufacturing establishments records an increase in value of products of 45.2 percent in 1937 compared with 1935.

The Census Bureau collects detailed production statistics primarily on the basis of classifications suggested by industry, through its trade associations. The data from the 1937 Census of Manufactures now in process of tabulation will reveal information on a number of additional types of plastics not separately classified in 1935.

These bare facts from the U. S. Census of Manufactures constitute the statistical story of more than a half century of plastics as an industry.

TABLE 3. PRODUCTION OF SPECIFIED FABRICATED PLASTIC PRODUCTS, 1935

Industry	Products	Value of Products	Quantity
Synthetic-Resin, Cellulose-Plastic, Vulcanized-Fiber and Molded Pressed Pulp Fabricated Articles, not Elsewhere Classified	Laminated sheets and plates (made for sale as such)	$4,169,900	....
	Laminated tubes, blocks, and other unfinished forms (made for sale as such)	597,716	....
	All other laminated synthetic-resin products	5,912,006	....
	Molded products	21,038,026	....
	Other synthetic-resin products and finished cast products	2,266,109	....
	Nitrocellulose articles, not including bags, wrappers, etc.	3,271,878	....
	Cellulose-acetate articles, not including bags, wrappers, etc.	1,079,400	....
Boot and Shoe Cut Stock and Findings	Celluloid-covered finished wood heels	2,954,210	3,251,618 Doz. prs.
	Counters	7,251,981	....
	Box toes	2,946,522	....
Brushes, Other Than Rubber	Toothbrushes with handles or backs of cellulose compounds	6,057,970	....
	Toilet brushes with handles or backs of cellulose compounds	2,590,239	....
Buttons	Buttons of cellulose compounds	1,579,709	724,876 Gross
Dentists' Equipment and Supplies	Denture materials, except rubber	487,661	....
Mirrors and Other Glass Products Made of Purchased Glass	Laminated glass (principally safety glass)	53,282,938	....
Optical Goods	Spectacle and eyeglass frames, mountings, and parts of Zylonite or shell, with or without metal parts	2,125,718	....
Paints, Pigments, and Varnishes	Plastic paints	781,167	13,220,232 Pounds
	Lacquers	54,265,949	42,278,656 Gallons
	Drying japans and driers	1,705,163	1,850,588 Gallons
	Bleached shellac	2,425,032	12,524,732 Pounds
Pencils, Lead (Including Mechanical), and Crayons	Pyroxylin mechanical pencils	3,663,138	125,146 Gross
Pens, Fountain and Stylographic	Pyroxylin fountain pens	10,898,965	140,483 Gross
Photographic and Projection Apparatus	Films (motion-picture and other)	41,027,068	....
Radio Apparatus and Phonographs	Phonograph records and electrical transcriptions	3,705,016	....
Rayon and Allied Products	Rayon yarns	146,067,470	257,557,347 Pounds
Roof Coatings Other Than Paint	Fibrous plastic roof cement	1,314,167	33,216,585 Pounds
Surgical and Orthopedic Appliances and Related Products	Adhesive plasters	$3,091,769	....
Toys, Games, and Children's Wheel Goods	Pyroxylin toys	360,125	....

Source: U. S. Census of Manufactures, 1935.

AUSTRALIA

(*Continued from page 5*) type of tool is not available, the user makes it himself. Similarly, where powder flow cannot be readily altered the molder so adjusts his temperature and cycle that he is able to use it.

The interchanging of ideas from one country to the other, both by visits and magazines, has helped the molders to keep abreast of current trends. The result is that where practical these are incorporated into the molding plant. Although there are at times different ways of doing the same job, on account of production numbers, it is not always practical to use them. Australia is doing a particularly excellent job in building the plastics industry, and is destined to go far, and fulfill the ever-growing demands that are being made upon it.

ENGLAND

(*Continued from page 6*) wherein darker portions of the illustration are thicker and naturally more opaque.

As regards the future I do not think that injection will wipe out compression molding entirely; both will in the future be of equal importance. It will be found, however, that as bulk requirements increase for thermoplastic materials and further competition arises, prices will gradually decrease to the level of thermosetting resins. Further, thermosetting materials will soon be prepared in a condition that will make them suitable for injection molding purposes. This will also be the means of equalizing prices per pound. In any case in another ten years or so, we shall probably see some extraordinary variations from our present methods, and I should not be surprised to find gravity or air pressure fed moldings of, say, up to 1000 lbs. each being molded at one shot.

GERMANY

(*Continued from page 8*) and doors of phenolic resin. Vinyl polymerization resins have found widespread use in floor coverings, collapsible boats and synthetic leather. Since quite recently, they also serve for insulating buildings against humidity. For constructing a tunnel, for instance, the upper sides of the slabs of concrete used are covered by a 0.5 mm. foil of a polymerization resin, and the slits between the slabs are packed by an elastic, rubber-like strip of the same material.

Plastic seals for locking packages, measuring instruments and railway wagons, while having all the advantages of lead, have the additional advantage that they can be applied by hand. Plastic printing type, made of a polymer, is ten times lighter than lead and is not poisonous. Plastic artificial teeth as recently developed in Germany can be easily manufactured, by every dentist, with the necessary close tolerances. They can be adapted to the color of the natural teeth of the patient and resist food, drinks and tooth-paste while being much more solid than porcelain, the more so when provided with an insert of a precious metal alloy.

In molding polymerization resins, the injection process has rapidly gained in favor, about 200 German companies now being active in this field. Tolerances are being reduced more and more, with a consequent increase of the number of uses to which the products may be put. It is impossible not to be thrilled by the recent rapid development of the plastics industry, but it is likewise impossible to describe in detail the multitude of novelties that have come out in the past twelve months, the more so if we include the machinery developed for the use of the plastics industry. The Eckert & Ziegler machines with which injection moldings of up to 150 grams weight can be produced, the most varied presses, "Spektral-Photometer" for exactly defining the colors of plastics, and copying milling machines considerably reducing the cost of making molds, may only briefly be mentioned here.

ITALY

(*Continued from page 9*) manufacturer of chemicals started the manufacture on a commercial scale and the distribution of this product had a rapid start. The greater part is supplied for aeronautic constructions, but a good deal is destined also for decorative purposes and especially for coating counters and other bar furniture.

At the end of 1937 a big plant for the manufacture of "organic glass" methacrylate resins, was started and the product has been successfully tested by the aeronautic industry as a substitution for ordinary glass. This product is further being introduced in the manufacture of spectacles and decorative articles, where it finds interesting applications owing to the fact that it is easy to engrave with fine drawings.

In the field of propaganda and publicity too, the period 1937–1938 has marked considerable progress for the Italian plastics industry. The chief manufacturers displayed their plastic articles in all important exhibitions and shows. The pavilion of plastic materials at the Milan Show in April 1938, organized for the third time by the Review "*Materie Plastiche*," was of particular importance. It contained a big molding plant and a rather interesting display of a large variety of molded articles, which were rewarded with a great interest shown by authorities, as well as by a great number of technical people who visited Italy's largest Show.

It is also worth mentioning that here in Italy, as in Germany, the wide use of plastic materials represents an important factor in reaching economical independence. In fact, plastic materials and especially synthetic resins, which are no longer dependent upon foreign raw materials, will advantageously replace a large tonnage of superior woods and metals, which have formerly been imported for lack of availability in the country.

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PAGES 15 TO 172

MATERIALS AND METHODS

PHOTOS COURTESY ROHM & HAAS

Acrylic resins are distinguished by their transparency. Boxes above are molded of Crystalite by Kurz-Kasch, Inc., while Consolidated Aircraft Corp.'s XP82Y-1 is equipped with Plexiglas windows, turret, and cockpit enclosure

ACRYLIC RESINS

by DR. D. S. FREDERICK

THE RESINOUS PRODUCTS OBTAINED BY THE polymerization of the monomeric derivatives of acrylic acid are known as the acrylic resins. This group includes acrylic and methacrylic (alpha-methyl acrylic) acids, their esters, amides, salts, halides, and nitriles. From a commercial standpoint, the esters are of most importance at the present time.

The industrial development and application of the acrylic resins have been due mainly to the research of Dr. Otto Röhm of Darmstadt, Germany, who, with his collaborators, has continuously worked with these materials since his original publication with Von Pechmann in 1901. Recently many publications on these products have appeared in academic, industrial, and patent literature. Various methods of preparation of monomeric esters have been described; the essential starting materials for most of these syntheses are petroleum, air, coal, and water. The monomeric esters are manufactured from readily available organic chemicals by a series of reactions which involve several carefully controlled steps.

The monomers are converted into polymeric resins by the action of catalysts including light, heat, oxygen, and oxygen yielding compounds such as organic and inorganic peroxides. Antioxidants such as hydroquinone act as polymerization inhibitors. Since acrylic and methacrylic esters of several alcohols are available, and since the polymerization conditions including the amount of catalyst, polymerization temperature, and concentration of monomer, affect the properties of the polymeric esters, acrylic resins possessing a wide range of properties are available. Products varying from soft, sticky semi-liquids to hard, tough, thermoplastic solids can be prepared without the use of plasticizers; hence the acrylic resins are not handicapped by the disadvantages which the customary use of a plasticizer introduces. Extraordinary colorless transparency, stability against aging, thermoplasticity, and chemical resistance to many reagents, are general characteristics of the polymeric esters.

Acrylic resins are available in the form of solutions in organic solvents, aqueous emulsions, cast rods, sheets, and tubes, molding powders, and molded sheets. We shall discuss separately the properties and uses of each form of these materials.

Solutions

The laminated glass industry has for several years employed the acrylic resins as an intermediate layer in the manufacture of safety glass. For this application, viscous solutions of the acrylic resins in organic solvents are used. A film of the resin solution of carefully controlled thickness is applied to each sheet of glass to be laminated and the solvent removed by forced drying, leaving a film of dried gum on the glass. This film is moistened by a suitable contacting agent, and the resin coated glass sheets placed together in such a manner as to force out all air bubbles. The lamination is completed by subjecting the assembly to a relatively low pressure to insure a firm and uniform bond.

This comparatively simple laminating procedure eliminates the necessity of autoclaving at high temperatures and pressures, and facilitates the avoidance of contaminating dirt, which always constitutes a serious problem in working with transparent plastics. The colorless transparency and freedom from haze of acrylic-laminated glass is unequalled by glass laminated with any other plastic. The adhesion of acrylic resin to glass is so good that, although no sealing compound is used around the edges of the laminated sheets, prolonged immersion in boiling water causes no delamination. Since the acrylic film is quite flexible, acrylic-laminated glass can be cut very readily by merely scoring and breaking both sheets of glass and then cutting the resin film with a sharp instrument. The elimination of edge sealing and the ease of cutting facilitate the use of odd shaped and odd sized sheets of acrylic-laminated glass.

Their excellent adhesive qualities and outstanding aging properties make the acrylic resins well suited for protective coatings. Films of (*please turn to page 126*)

CASEIN PLASTICS*

by T. L. BIRRELL, M.A., B.Com.

THE CASEIN PLASTICS ARE MANUFACTURED IN Great Britain (under two trade names) and essential steps in manufacture are well known. High-grade rennet casein in powder form is thoroughly mixed with the appropriate amount of water and necessary coloring matter. The water is absorbed by the casein and might perhaps be described as the plasticizer of the casein. Other chemical additions are sometimes made for special purposes.

The mixture is then fed into screw extrusion machines, from which it is extruded under high pressure through a heated nozzle. The product is a rod or tube, soft and plastic when hot but hardening on cooling. It is cut into standard lengths. Sheets may be formed by further mechanical operations on plastic rods, either by pressing them directly into sheets in shallow molds in hydraulic presses or by making them into a block which can be cut into sheets on a slicing machine. There are various ways of configurating colored batches of casein material to produce patterns.

The plastic tubes, rods or sheets are hardened by steeping them in a dilute solution of formaldehyde. This process has a sterilizing action, preventing the bacterial decomposition of the casein, but it does more than that. If the material, after extruding or pressing, were left without further treatment it would rapidly lose moisture and become quite useless. The formaldehyde overcomes this and stabilizes the product in a variety of ways; it undoubtedly reacts chemically with the protein molecules, producing a material considerably more resistant to water and change of shape than casein which has not been formolated. When the penetration of the plastic by the formalin is complete (the time for this naturally depending on the thickness of the material) the sheets, rods and tubes are transferred to drying rooms, where the excess moisture is gradually removed. During this process there is some shrinkage in volume, and a certain amount of warping is corrected by straightening and flattening the products after they come from the drying stoves. The time necessary for thorough drying, like the time for formolation, depends on the thickness of the sheet, rod or tube.

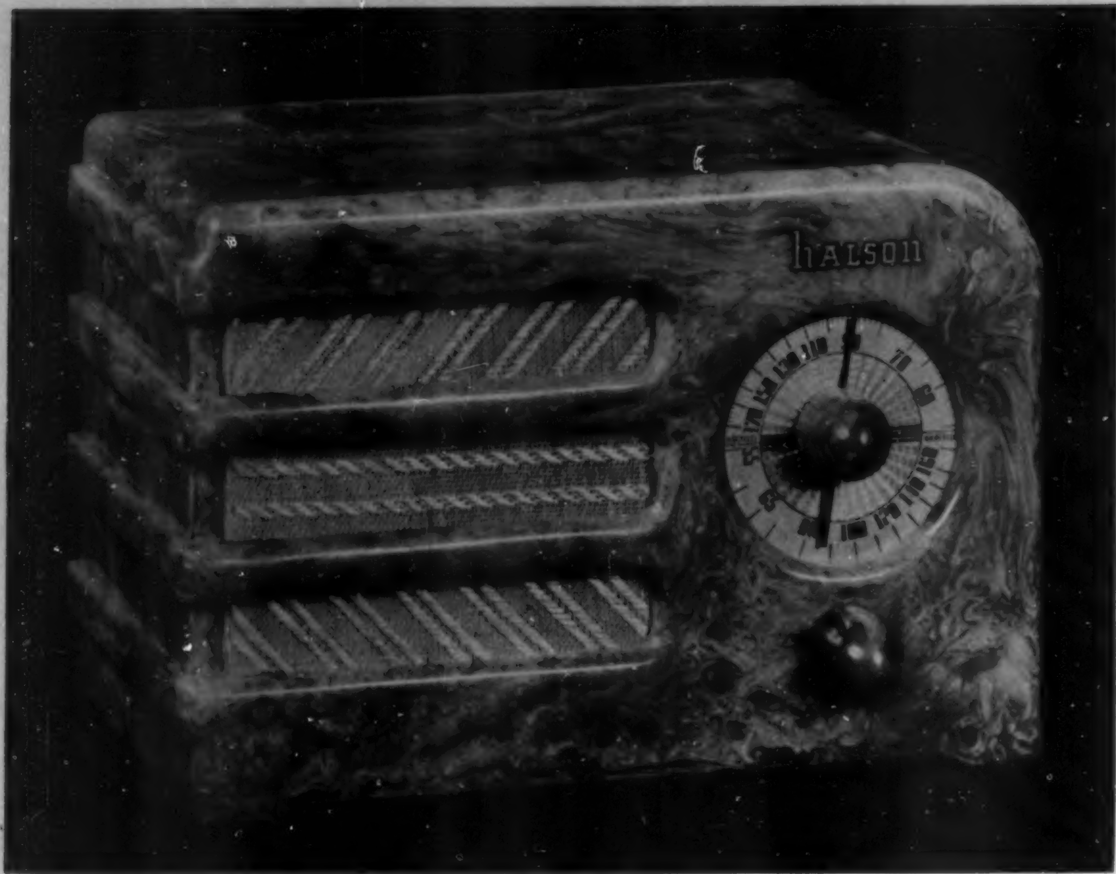
It will be seen that the essential ingredients are rennet casein and formaldehyde. The coloring matters, although they have to be carefully selected for fastness and brilliancy, do not present any special problems separate from those of the plastics industry as a whole.

Rennet casein is made from skimmed milk (after separation of the cream) and the industry reaches large dimensions in France, Denmark, Holland, New Zealand and the United States. The world production of casein is estimated to be about 70,000 tons, but it is not known what proportion of this is rennet casein. Lactic casein is much inferior as a plastics raw material. Rennet casein for plastic manufacture must pass a very stringent specification, and until recently practically no casein of suitable quality and price was produced in Great Britain. There is every sign that efforts are being made to correct this position. It may be pointed out, in passing, that the view that the casein plastics industry is depriving the country of an essential foodstuff is quite erroneous. It is a fact that the cream is separated from the milk before the casein is manufactured, and the whey which remains after the casein curd has been produced by the addition of rennet is a source of milk sugar, i.e., lactose. It has many uses, particularly in a national emergency. For the production of one pound of casein about $3^{1}/_{4}$ gallons of skim milk is necessary. So far as this country's production of dairy produce is concerned, casein plastics take very little, but in any country the existence of a demand which is able to absorb the products made from an excess of milk production helps to stabilize the dairy industry. There is far too much internal competition between different plastics for manufacturers of casein to be able to offer fancy prices and thereby affect the quantity of milk available for human consumption.

Formaldehyde is produced in this country by the oxidation of methyl alcohol, (*Please turn to page 132*)

Cosmetic and lipstick containers are frequently turned from casein rods and tubes. These are from A. J. & K. Company

*Reprinted by permission from the January, 1937 issue of *I. P. I. Transactions* the Official Journal of The Institute of the Plastic Industry, Great Britain.



Cast resins for radio housings are comparatively new but their translucence, brilliant color and unified construction presage rapid advancement in this field. The Halson pictured above is a recent arrival in the radio market. (Photo courtesy Monsanto)

CAST HOUSINGS FOR RADIO

by KARL J. EKLUND

IN RETAIL RADIO STORES ACROSS THE COUNTRY, cast phenolic resin is winning a new place for itself in the plastics sun as a vital sales-making influence. Mr. and Mrs. Consumer, to whom the names of most plastics materials are Greek and their methods of fabrication a closed book, find the texture and beauty of cast resin an irresistible attraction when they are in a buying mood.

Enough evidence is now in, backed by retail sales results, to prove that this material is due for an increasing importance in the production of radio cabinets and other products depending on eye-appeal for sales success. It is increasingly apparent that this element of appeal is great enough to more than offset any increased cost, even though passed along to the buyer in the retail price.

Analysis of the current popularity of small "occasional" or table model radios in plastics cabinets, shows clearly that the efficient operation of the chassis itself is taken for granted and that the emphasis in the buyer's mind is all on the external appearance of the set. The fact that a radio cabinet will harmonize with the color scheme of a room is equally as important as the number of tubes inside it.

In any situation where appearance plays so large a part, cast resin inevitably enjoys an advantage. It possesses outstanding beauty, together with an almost unlimited range of colors and possible color combinations. With the designer's palet decked with a choice of solid or mottled colors, opaque, translucent or even transparent, he has free play for the creation of effects not possible with any other materials. Too, cast resin permits the designer to go to the full lengths of his ingenuity in producing new and striking shapes—a point equally as important as his use of color, since eye-appeal is influenced by line as well as shade.

From the standpoint of the fabricator and radio manufacturer, cast resin presents no difficult processing problems and some major advantages. It can be produced at an exceedingly low mold cost, as compared with pressure molds. Likewise, such molds can be delivered more quickly, with consequent speedier production

of finished cabinets. New designs can be introduced more often, since mold expense is lower, thereby permitting a manufacturer to be "fast on his feet" in the production of designs geared to the public fancy.

The ever-haunting need to attain huge volume on any one design, in order to spread expensive mold costs over a large number of units, is largely dissipated. There are many instances on record where temporary molds have been made and sample cabinets cast, cured, finished and delivered in twelve working days. The one adverse element of greater cost in cast resin is offset partly by lower mold costs, and offset even more by the merchandising opportunities afforded by greater flexibility in the use of molds and increased eye-appeal for the public.

Acoustically, cast resin has been proved in thorough tests to be the equal of any plastics cabinet material. Thousands of hours of continuous radio operation have failed to injure or discolor in any way the properly designed cabinets made of these resins. Although comparatively new to the radio industry, cast resins have already established their own practical technique in casting and finishing.

Such requirements as draft, balance and ventilation in casting have been met fully. To stand up under constant use without change in shape, molds of special alloy steel have been developed. Many of these master molds are identical with their condition when first used, after casting many thousands of cabinets. In finishing processes, new techniques have been applied and are now as thoroughly accepted as those used in the handling of other plastics materials.

After the cabinet casting, averaging in weight from $1^1/_2$ to $3^1/_2$ pounds, has been ejected from the lead, the first operation is deflashing. This is done on a special machine which holds the cabinet in proper location, feeding it against a large cutting wheel. Such a wheel, revolving under several heavy streams of water, cuts off the flash to leave the top, or front, of the cabinet smooth and ready to polish. This process also provides for exactly the specified height and thickness.

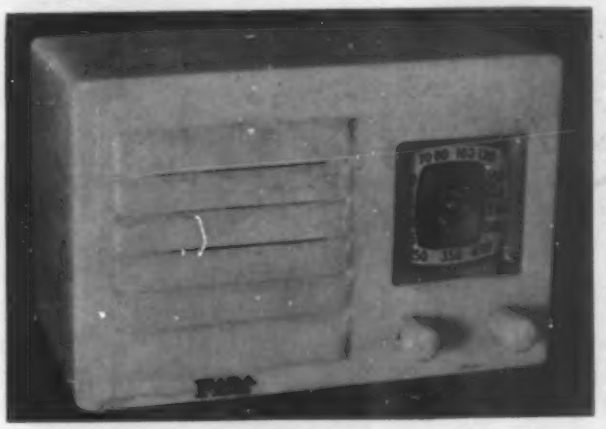
Cabinets are then shaped around the outer edges and around the speaker grille, through use of a vertical shaper with cutters running at several thousand revolutions per minute. The cabinet is held in a fixture which controls its location so that the shaping cutter accurately cuts to the right dimensions, producing the desired edge or corner effects. For intricate cut-out designs, the operation is repeated until two or three steps in the cutting have produced the desired result.

Drill jigs and locating fixtures provide precision in drilling the cabinet for chassis-attaching bolts, backplate screws, feet holes and loud-speaker support, when required. Such precision methods are especially desirable when sets are produced on assembly lines, requiring accurate fitting of parts. The usual touching up, completing the production processes, are performed much the same as on other cast resin products. These include ashing, roughing and polishing, all done with the reasonable care necessary on an object as large as a radio cabinet.

Oftentimes, specifications call for unbreakable crystals of cellulose acetate or cellulose nitrate. These can be cemented to the inside of the dial opening, which is incorporated in the casting itself. Here again, new requirements have brought new and effective methods, for a special cement has been developed to unite cellulose crystals and cabinets. Its use eliminates the need for bezels or other crystal-holding devices.

With fabrication technique so fully advanced, cast resin may fairly be considered as being in a position to widen rapidly its already established place in the radio industry. Certainly its distinct advantages in beautiful colors and finish are in tune with the times . . . and in tune with the bells that tinkle on a million cash registers wherever goods are sold.

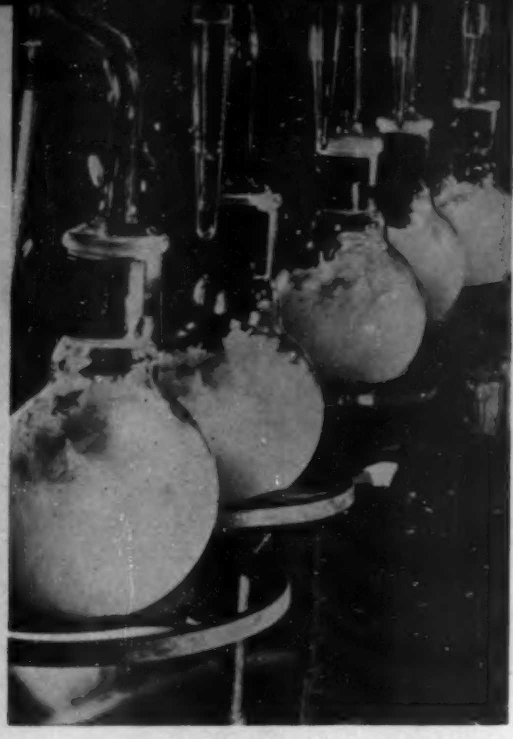
1



2

3

Fig. 1.—Fada radio with Catalin cabinet
Fig. 2.—Emerson model housed in Fiberlon
Fig. 3.—New Tom Thumb table model of Catalin



Left: Three years were spent in developing an ideal cast phenolic resin for these brush backs. Right: Color extract test in the laboratory. (Photos courtesy Catalin)

CAST PHENOLIC RESINS

by D. K. BANCROFT

CAST PHENOLIC RESINS WERE BORN IN THE RE-search laboratory and every inch of growth, every improvement in character has come from the same source. The process of making these materials has been described in stories, photographs and moving pictures. It has been explained that phenol and formaldehyde are reacted with caustic soda until the resin forms, that the resultant product is then acidified, and that at this point the mixture resembles light butterscotch syrup; that color is then added and the agitation continued until the liquid is on the verge of reaching the gel stage; that the resin is then poured into lead molds and cured anywhere from 4 to 12 days in ovens or vulcanizers, under accurately controlled temperature, until it reaches the proper hardness; that the castings as they are forced from the molds with pneumatic hammers are immediately ready for shipment and fabrication.

All this is more or less familiar to users or prospective users of cast phenolics, but the element of research which has made it possible, is not quite as well known. Simple as the process sounds, it is not a matter of taking a portion of this, and a bit of the other, at the discretion of the operator, mixing them together and hoping the result will be cast resin. Not at all: Every factor—the proportion of each ingredient, the chemical reaction, and curing time—has been studied, checked and double-checked by the research laboratory before ever a phenol molecule meets a formaldehyde molecule and is properly introduced by the catalysts.

Nor can research activities, once a workable formula has been evolved, be discontinued. All manufacturing is a matter of continuous research toward the goal of satisfying constantly changing desires of consumers. This is particularly true of plastics, which have undergone great improvements during the past decade. Naturally, demands have increased and expanded much faster, in comparison, than they do for merchandise or materials that have been on the market for a long time and are well known. One of the problems of the plastics supplier is to keep up with the designer or manufacturer who has a bright idea that he would like to use the material for a certain purpose. Once he decides upon it, there is no changing his mind. He is going to find a plastic that will do the job, and right at this point, the chemical and research laboratory comes into the picture. If no formula exists which covers all the desired characteristics of the application, a new one may shortly be expected to appear.

One of the many advantages of plastics is that since they are man-made, they can be custom built for an individual job or class of product. Such flexibility would be hard to find in a natural substance. A tree, for example, is a natural material and different kinds of trees yield hard wood, soft wood, pitchy wood, or dry wood, perhaps none of them exactly right for the item in mind. You can't make a new tree that will give a new kind of wood with just the properties you want. But when a plastic shows a weakness in any one of its physical qualities, which prevents its use for a specific application, the chemist does something about it. He attempts to bring out that additional quality without sacrificing to any great extent the other (*Please turn to page 134*)

CELLULOSE ACETATE

by JOHN B. SCHEER

IN THE PAST FEW YEARS, THE INCREASE IN THE use of cellulose acetate plastics has been nothing short of phenomenal. Starting from "scratch" on the eve of the worst business depression our country has ever known, this material has progressed steadily, both in variety of applications and in the total amount used. The many advantages offered by cellulose acetate plastics are reflected in their selection for the manufacture of many widely different types of articles.

Prior to the advent of injection molding, cellulose acetate plastics, being molded by compression, were limited in use. The injection molding process, however, offering the advantages of high speed production and comparatively low cost molds, brought cellulose acetate plastics into their own. This union has established a new method of molding in which cellulose acetate plastics, judged by the scope of their utility, are unequalled.

Strength and resiliency, however, are probably the most practical contributions of these plastics to the products which they serve. The term "strength" is broad in meaning but, as applied to cellulose acetate plastics, the reader should understand that we refer specifically to *impact strength*, or resistance to breakage. Resiliency is the capacity of a strained body to recover its size and shape after deformation. The combination of this strength and resilience in the cellulose acetate plastics, plus their adaptability to injection molding, have opened up many fields of industry to them which, before their discovery, were closed to plastics in general.

An excellent example of this is the use of cellulose acetate plastics in the automotive field which was the first to realize their possibilities for practical applications. Let us consider the reasons why this industry accepted them. For years, automotive engineers and designers have been noted for their exacting demands in the quality and suitability of materials used, and for their painstaking research in tracking down the materials to fit those demands. Their specifications of color and strength for molded parts are no exception to the rule.

Shade of color is their first, although not the most important, consideration in the selection of plastic appointments. No effort is spared in choosing the proper shade to harmonize with the color scheme of the interior and to enrich the beauty of the car. Variegations, or mottled color combinations, have been used extensively for these applications, and are a special feature of cellulose acetate molding compositions. Steering wheels, door handles, window regulators, dashboard panels, gearshift and control knobs, have thus become a part of the car's decorative scheme *(Please turn to page 168)*

No reason why a carpenter shouldn't have a colorful handle on his saw and other building tools. His approval has been well expressed in increased sales since Henry Disston & Co. began using saw handles molded from Lumarith and Tenite, cellulose acetate materials, which are tougher than wood and are easier on the hands (Photo courtesy Tenite)

CELLULOSE NITRATE

by HAROLD K. HAVILAND

MUCH HAS BEEN WRITTEN IN THE PAST seventy odd years on the subject of pyroxylin, cellulose nitrate plastics. Its history, chemistry and process of manufacture are well known having been adequately presented elsewhere and also in previous issues of this journal. This article will be concerned more with the general significance of the pyroxylin plastic and the part it has played in the plastics industry.

It is interesting and in fact amazing to note that pyroxylin plastic is today substantially of the same composition as when invented by John Wesley Hyatt over seventy years ago. True, the stability and purity of the raw materials pyroxylin, camphor and solvents have been greatly improved. Hyatt's success was due largely to the fact that he employed only the purest materials available at that time. His aim was high; he sought to create a substitute for the diminishing supply of natural ivory used for billiard balls. The industry has followed Hyatt's example and has ever employed chemists and research workers to develop purer and finer materials for truly quality products, so that today the pyroxylin plastic is infinitely stronger, more stable and of better color than the original material. However, the plastic is still essentially a composition of pyroxylin and camphor. Chemical science has not yet succeeded in providing an entirely satisfactory substitute for camphor, although it has produced synthetically the natural camphor.

While chemistry has played its part, the development of pyroxylin plastic has not been wholly independent of mechanical methods or appliances invented for its manipulation. So it has been said, and truly, that the plastic owes as much to the mechanical art as it does to chemistry. It is an off-spring of their happy union. In fact the inventor was particularly renowned in mechanical fields as the originator of the Hyatt roller bearing. Kneaders, filters, converting rolls, stuffers, block presses, planers, finishing presses—Hyatt saw all these developments during his time. Here again many improvements have been made and new methods developed for working the material into new colors, configurations and shapes, but the equipment and process are today fundamentally the same as used in the beginning. That this is so is indeed a tribute to the industry and genius of the inventor of this material and his contemporaries.

Hyatt's earliest attempt to supply the urgent demand for a substitute ivory billiard ball was a compressed mixture of paper fiber and shellac coated with an ivory-like surface of dissolved pyroxylin made white with suitable pigments and colored with appropriate dyes. The pyroxylin composition which formed the billiard ball surface was applied in the liquid form and hardened by evaporation of the volatile solvent used. Such compositions were naturally limited in application due to restrictions as to size and thickness. His later discovery of the thermoplastic nature of pyroxylin when mixed with camphor and a limited amount of solvent led to the temporary abandonment of the earlier processes which aimed to produce such a substance from solutions of more or less liquid consistency. It was recognized that the difficulties which beset these early endeavors were partly due to the limited choice of solvents then known. With the discovery of new liquid solvents of sufficienty varied character to afford a range of choice, the process of evaporation to a solid condition was so controlled as to transform many of the former failures into success. Among the notable contributions of this period was John H. Steven's discovery in 1882 of the solvent action of amyl acetate for pyroxylin. The field of application was, however, preferably confined to the deposition of protective coatings from solutions applied by dipping or brushing, or to the formation of thin sheeting by spreading slow flowing dopes on a surface and afterwards stripping off the dry product in the form of a sheet.

Following the application of these new solvents there was a great development in the manufacture of lacquers, varnishes and thin sheeting for photographic purposes. Under the new conditions which followed this rebirth of the liquid processes, chemistry again depended upon mechanical aid. The outstanding example of this was Steven's and Leffert's inven- (*Please turn to page 138*)

Typical uses of cellulose nitrate plastics are shown below. The draughtsman's tools at the left are Celluloid while the zippers (center) and dresserware (right) are of Pyralin




Preforming (left), loading with pill board (2 center), removing molded parts (right) from a semi-automatic press in the plant of the Boonton Molding Co.

COMPRESSION MOLDING

by GEORGE K. SCRIBNER

THE RAW MATERIALS OF THE PLASTIC MOLDER arrive at the press in various stages of bulkiness, the descriptive gage of which is covered by the term "bulk factor." Some may resemble granulated sugar in size and shape of particles, with a bulk factor or ratio of volume before and after molding of two and a half to one, some may be like a pile of rumpled one inch squares of canvas, which, in fact, they are, with a bulk factor as high as eight to one. One of the problems of the molding operation is to place this material in a confined space so that none can escape and to force it into its desired shape through the application of high pressure and moderate heat.

Some of these materials can be preformed into slugs or pills so the bulk at the time of introduction into the mold is reduced to one and one-eighth to one, provided the part to be molded lends itself to this treatment, as not all of them do. The really high bulk factor materials, however, cannot be preformed comfortably and economically. It requires practically a separate molding operation to reduce their volume with a consequent cost that is often embarrassing. In such a case the top of the mold cavity must be extended upward enough to form a basket of sufficient size to hold the raw stock with only a moderate amount of placement by the operator.

The reduction of this raw volume of material to the final molded form can be done by several methods, sometimes depending on the type of material to be used, sometimes on the shape of the piece to be made. If the material is placed in a chamber separate from the mold itself, heated, and then forced through small orifices into the mold which confines it to its proper shape, we have injection molding. This term is usually applied only to that group of materials which become viscous when hot and hard when cold, called thermoplastics. In that case the mold is maintained at a temperature closely approximating the hardening temperature of the material so that the material starts to set as soon as it hits the die. The same method can be used on the other type of materials known as thermosetting, which soften under heat at first and then harden because of a chemical reaction. In this case the method of molding is called transfer molding, instead of injection.

So far, both of these methods are of relatively small application in the trade on the basis of actual pounds of material converted. The most active method and the oldest is that of compression molding. Here the material is placed in a container from which one side, usually the top has been removed, the sides are extended high enough to hold the material from spilling over, and the top is forced down into place, pushing the material ahead of it. There are enough complications in this simple action, heaven only knows, but it is kindergarten work alongside of the other two processes. Compression molding requires the cheapest press assembly, and allows the cheapest mold construction, under average conditions, hence its popularity.

The container used is made of hardened, ground, polished steel because pressures applied are of the nature of 3000–5000 lbs. per square inch. It is hardened to stand such enormous pressure without losing its shape, ground to get exact dimensions (organic chemical reactions are hard enough to keep within given dimensions without starting with irregular measurements) polished because the material will not come free from or flow freely over a rough tool-marked surface and will show in detail every minute mark left on the steel.

The simplest variation of compression molding involves the use of a separate mold or die which is self-contained and designed to be manually handled by the operator. It is loaded on the bench, capped, placed in the press, closed and cured there, and then removed for opening under an arbor press, or in some rough operations, with a sledge hammer. This latter procedure is not particularly good for the mold and is definitely not recommended. The same mold in most cases, with some



Removing threaded part from hand mold (left), trimming flash with file (center), and polishing the part (right) at the Boonton Molding Co.

structural modifications, can be bolted permanently into the press and opened and closed as the press itself opens and closes. The press must have a positive up and down movement under pressure instead of the usual gravity drop found in the standard hand press.

In spite of the trend toward semi-automatic presses found in all up-to-date molding shops there will always exist a large group of parts that do not lend themselves to such wholesale treatment, either because of fragile inserts, delicate molded sections, or some similar reason. A complete molding shop must have a full selection of types and sizes of molding presses so that each piece gets the treatment its design indicates, and is not handled according to the equipment available regardless of the results. Many jobs have failed because the molder used what he had instead of planning around the piece itself.

There are two great drawbacks to compression molding as compared to injection or transfer. The first is the fact that the mold is wide open when the material is put in and must be closed under great pressure. This material swirling around inside the mold at pressures averaging 3000 lbs. per square inch will do more damage than a combination flood and tornado, in proportion to its confined volume. Carefully hardened tool steel pins, one-half inch in diameter can be snapped off like match sticks if they happen to lie in the stream of moving material. Inserts are torn from their anchorage with the greatest of ease. Sometimes careful design of the mold with an eye on the probable movement of the material as it flows to its ultimate resting place will do the trick, sometimes it means a redesign of the part itself. It may even mean the abandonment of some particular raw material and the substitution of a less bulky form with more innate viscosity resulting in a consequent reduction in such qualities as shock resistance. The second drawback of compression molding is the fact that more material is placed in the mold than is required for the final piece. The surplus comes out all around the down moving plunger as a thin flash. This flash will usually be thicker than the molder wants to handle in the first place, and gets thicker throughout the life of the mold because of inevitable wear of the mold. This flash must be filed off, usually by a hand operation. Automatic finishing machines are rare in the molding business. The variations in dimensions, small as they may be, are too great to help much, and the material is too tough and abrasive to work unless a straight grinding action can be used. Since one of the great advantages of molding is the ability to make peculiar and unusual shapes in quantity the pieces do not have enough regularity of outline to allow automatic devices without the expenditure of more money than the saving permits. The average cost of finishing compression molded pieces runs to about two-thirds of the cost of molding.

In transfer or injection molding this difficulty is minimized greatly. The mold is closed and the material is forced into it. The result is that little or no flash occurs at any place except where it actually comes into the piece, called the gate. It is quite true that the sightly removal of this gate often presents embarrassing problems, but since there is usually a wide choice of locations for this gate available at the time the mold is laid out, it can be placed at some point where it will do the least harm.

The simplest design for compression molding is obviously a part that has no undercuts, from which the plunger can be withdrawn directly, and which will come free from the enveloping chase without getting hooked under any odd pieces of the chase in its upward movement. This is not a requirement in the operation of the press, it is a matter of economy. Undercuts and side holes can be put in. When they are, side pins must be moved back and forth before the mold is opened, side plates may have to be ejected as an integral part of the piece and taken off the piece outside the mold, after which they are returned to their proper position in the mold ready for the next operation.

The molded part may have to be removed from the chase by ejector pins which will leave a mark on the surface. It is almost impossible to join two pieces of steel in contact with the molded surface without a mark appearing on that surface. When such marks are not permissible on a given surface slight undercuts are placed on the plunger so the piece tends to stick there when it is withdrawn. Then it is knocked off the plunger by ejector pins. In some special cases a blast of air will bring it out of the chase or off the plunger without disfiguring scars.

There are two costs involved in all these operations—the man's wages and the wages of the press unit. Since all these added twitches take time they run into money. If the buyer must have them and can afford to pay for them, the sun shines brightly for everyone, but if he must have them at the price of a straight molding job we

Tumbling barrels (above) and automatic reamer (at right) used in finishing molded parts

get cloudy weather and, frequently, bad storms. Ingenuity on the part of the molder in laying out his mold may soften the impact of added cost but careful design by the customer in cooperation with the molder is the most important solution. Practically any piece can be molded—of practically any material. The real difficulty arises when the piece is to be removed from the mold. While the job is in the press it is ideal, perfectly flat, no blisters, no cracks, no troubles. The moment we start tinkering with the mold we start walking the tightrope. The molded part should come from the mold freely and ready for use after slight flashes have been trimmed off. Actually there are at least fifteen major diseases that may cause rejection or at the least excessive dissatisfaction, ranging through blisters, porosity, warpage, cracking, "frog-skin" surface, pitting, sticking, on and on up to number fifteen which may be a nice looking job but weak mechanically or electrically. By actual count of a chart there are at least fifty-nine causes of these fifteen defects and seventy-eight suggested corrective measures, distributed according to the various symptoms.

The operation of a compression molding cycle in a modern molding plant seems a very simple thing. To make it run so smoothly an enormous amount of expert staff work must first be done. From mold design to material choice and preparation the part has been laid out with care and the accumulated knowledge of many years and many errors. The process is kept in that path only by the constant and continuing application of that same accumulation of experience. Even the water in the hydraulic system is checked by chemists so they may prescribe antidotes for corrosive tendencies, and constant work is done on packings to cut down maintenance of the press and lessen costs due to idle hours.

A list of things not to do in designing for compression molding can easily be made out but at the end will come the best advice of all—pick a professional molder for the job, check his standing, equipment, and experience, then sit down with him and analyze your problem. Tell him what you want to do, why you must have certain features of construction, and then let him advise you that a radius here or a sharp corner there will mean hand work on the mold, even though after the mold is made it won't cost any more in the molded piece, that the section around this insert is too thin for comfort, that the undercut that seems to take care of all your assembly difficulties means an addition of fifty percent to the cost of the piece—perhaps worth it.

Final inspection requires trained hands and sharp eyes. (Photos courtesy Boonton Molding Co.)

You might read a book on "How to Remove an Appendix—and the Proper Tools Required," but you would hardly try it on anyone, even your mother-in-law, without a lot of previous experience. A molded job designed and built by amateurs can be as messy as such an operation improperly done. Too many articles are written purporting to give full instructions, one reading and you get your final degree, all with sad and expensive results.

The general technique of compression molding and the design of molds for this method is built day by day from the experiences in the molding plant in recovering from yesterday's headaches. We are doing with ease things that were impossible a year ago. This is the result of little mechanical kinks the shop men work out, of a better application of new steel alloys, and, perhaps greatest of all, of the rapid development of new molding compounds. Almost every day we get a notice of some new modification in a familiar compound. It seems as though at least every month we get a data sheet on a new chemical base which means an entirely new field of qualities and performance characteristics.

One last word of advice—Don't try to arrange a mold to make anything you may later want to use. Molds designed for canvas phenolics are cumbersome and slow with woodflour phenolics and ureas. Acetate molds (compression) are not so good with canvas phenolics—and so on. There can be a certain amount of interchangeability but if there is doubt on the material ultimately to be adopted—make an experimental mold, prove your problem, and design every step from there on to get the most economical run of the chosen material.

COUMARONE-INDENE RESINS

by ELLIOTT R. COYLE

COUMARONE-INDENE RESINS ARE SOME OF THE best known and most widely used synthetic resins. They are ultimately derived from bituminous coal by a long series of processes. In the by-product coking of bituminous coal the recovered light oil fraction yields a number of distillates, including a coal-tar naphtha boiling between approximately 150 and 200 deg. C. This crude heavy solvent contains the reactive chemicals, coumarone and indene. Further careful treatment with a polymerizing agent converts these chemicals by a resinification process into coumarone-indene resins. Many grades are made, each conforming to its distinct specifications. Manufacturing technique has been built up during years of experience and ceaseless endeavor to maintain the resins at their highest quality and supply every needed grade. These vary from viscous liquids to high melting solids, in colors ranging from pale yellow to dark red-brown or almost black. Average specific gravity is 1.08, which equals about nine pounds per gallon.

Coumarone-indene resins possess a number of properties, such as resistance to water, acids and alkalies which, coupled with their thermoplastic nature, render them desirable in molding plastics. That they have not found more extensive use for such purposes is due largely to their inherent brittleness and to the facts that the materials employed as plasticizers for them either had to be employed in such large amounts or were of such a nature that the resulting compounds did not bring out to the fullest extent the desirable properties of the resins.

Of the various synthetic resins, the vinyl acetate polymers possess such properties as would result, in blending with coumarone-indene resins, in marked toughening without detriment to the desirable properties of the coumarone-indene resins. Unfortunately, heretofore it has not been possible to use the two together because of their incompatibility. A newly developed commercial indene type resin, however, opens up prospects of new possibilities along this line. This resin (marketed under a trade name) is a phenol-modified coumarone-indene resin which in contrast to the ordinary coumarone resins is highly compatible with vinyl acetate polymers with the production of homogeneous thermoplastic compositions of unusual toughness. Relatively small amounts of vinyl acetate polymers are sufficient to toughen and eliminate the brittleness of the indene type resins.

Not only is phenol-modified indene-coumarone resin itself compatible with vinyl acetate polymers, but binary compositions are capable of blending compatibly with resins otherwise incompatible with vinyl acetate polymers but compatible with phenol-modified indene-coumarone resins, with the production of three component blends having desirable properties. It is possible in this manner to compound ordinary coumarone resins with vinyl acetate polymers. Through similar use of this new resin it is also possible to compound with vinyl acetate polymers other resins and plastic materials otherwise incompatible with them. All such mixes are suitably thermoplastic, tough and strong for molding compositions of the non-heat-hardening type.

Coumarone resins are stable and inert to the attack of many other raw materials when used in conjunction with them. They are neutral, and this negligible acidity is an excellent feature because it does not permit of reaction with basic pigments, fillers, etc. Coumarone resins are heat resisting and valuable in electrical insulation work, having high electrical breakdown, about 1400 volts per mil thickness, and a high dielectric constant. The higher melting grades of coumarone resins may often be used to extend high priced resins without detracting from their valuable qualities, and often will add desired characteristics to compounds. These special grades have found use with phenol-formaldehyde molding plastics for the production of such molded electrical parts as plugs, plates and toggles. A smoother finish, better tensile and dielectric strength, better impact resistance and the same fracture have been observed when using about 15 percent of the higher melting resin on the total resin content. An important property in this connection is that the electrical resistivity of materials containing high melting coumarone is less affected by moisture than is the electrical resistivity of rubber or mica.

Thousands of tons of coumarone resins are consumed annually by the flooring industry for the manufacture of mastic floor tile. Here the alkali-proofness and non-saponifiability of coumarone resins are primarily important, because such tile must withstand innumerable cleansings with soap and strong alkali scrubbing compounds. Lighter colored mastic floor tile has been made possible through the use of coumarone resins, and it will resist the attacks of soap, acid and water.

No attempt will be made in this brief article to cover the many widespread uses of coumarone resins which are not relevant to the plastics industry. Suffice to say that coumarone resins in common with other widely used synthetic resins find their way into varied industries and products, such as hot melt and solvent type adhesives, varnishes and many other coatings, fly ribbons, inks, rubber compounds and rubber goods, waterproofing uses, insulating compounds, and chewing gum.

DESIGN FOR MOLDING

by CARL W. SUNDBERG and MONTGOMERY FERAR

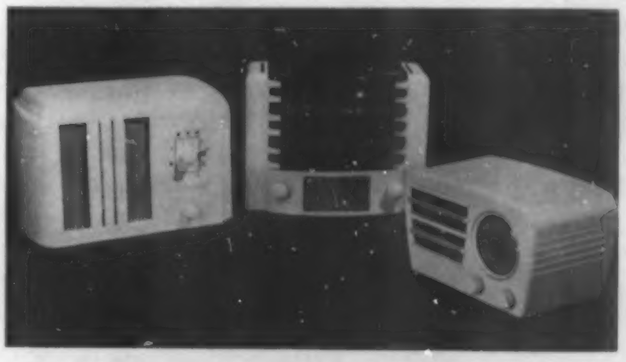
THE FIELD OF PLASTICS IS UNDOUBTEDLY THE one most susceptible to the skill of the industrial designer, who, sympathetic with his material can emphasize all the beauty of surface and freedom of form inherent in a plastic piece. This accentuation of surface quality to which plastics lend themselves so well, gives to any product an aspect of exterior beauty which symbolizes the internal good construction and workmanship of its manufacture. In competitive fields this emphasis on quality appearance must frequently be highly dramatized.

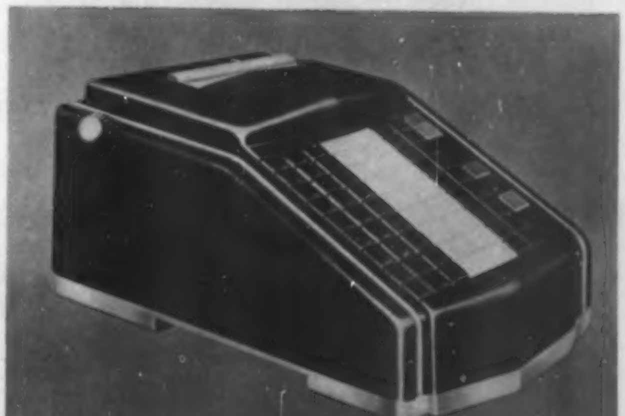
Artistic conception must be consistent with engineering facts. If a product costs more than formerly, or if its structural requisites have been violated, the designer is not of much value to his client. Sometimes because of his unfamiliarity with the factors which go to make up quality appearance, an aspect of cheapness occurs which results in consumer's sales resistance. It is only by working continually in the plastic field that one can be aware both of its possibilities and its limitations. This knowledge, plus the application of certain fundamental tenets of design and a certain flair for color and merchandising appeal, makes the designer valuable to the industry.

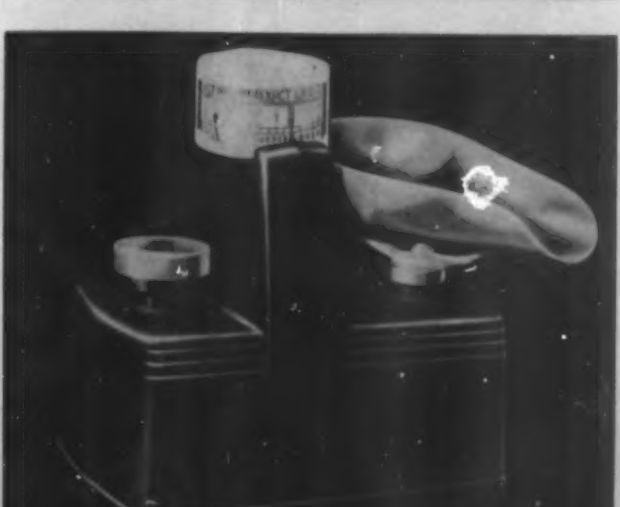
In design, as in engineering, the constant recurrence of difficulties of a particular nature bring forth certain laws or axioms to follow in the use of specific materials or processes. We have found, for instance, that rounded corners on a plastic piece have many advantages over sharp corners, as the latter are unpleasant looking in plastics and more susceptible to breakage and chipping. Crowned surfaces should not be used deliberately for the sake of "streamlining," but because they cause highlights on a piece and bring out the full luster and depth of the plastic surface. When a flat surface is necessary, it is often desirable to break it up by means of lines, steps, or beads, minimizing any irregularities of surface which might occur, and adding strength to the whole.

There is a dangerous temptation to apply ornament indiscriminately on plastic designs. "Applied" ornament results in the design looking overdone and unfunctional. Ornament should retain the functional machine-like character which identifies it with the plastic process. It should not be borrowed from classic examples used for entirely different materials, and subject to hand, rather than machine, processes. All materials and processes have their own functional language, whether it be stone, steel, glass, die castings, stampings, or machine fabrication. Appreciation of this functional language brings out the intrinsic beauty and fundamental rightness of plastics. It has always been our feeling that the tendency to imitate other materials such as wood, marble, or onyx, rather than taking advantage of the brilliance, depth, and translucency that plastics afford, is definitely bad design. Materials have their most effective and sincere expression when effects unique to themselves and possible with no other material are obtained.

The rapid strides made by the plastics industry this past year have opened up tremendous possibilities to the designer's imagination on one hand, and have ushered in on the other, the necessity to discipline that imagination with an intimate and thorough knowledge of the limitations of the process and the characteristics of the new material. (*Please turn to page 140*)







Designs illustrated are creations by Sundberg & Ferar which demonstrate the ability of plastics to conform to the modern theme of industrial designs

ETHYLCELLULOSE RESINS

by D. R. WIGGAM and WILLIAM KOCH

IN RECENT YEARS, SEVERAL ARTICLES HAVE APpeared in MODERN PLASTICS on the characteristics, preparation, and suggested uses of ethylcellulose plastics. An article in the October, 1936 issue,[1] pointed out the general characteristics of ethylcellulose, which indicated its suitability for use in plastics. In the October 1937 issue, Gibb[2] discussed the characteristics of some ethylcellulose plastics and indicated the general method of preparing them. These discussions bore particularly on compositions containing high proportions of ethylcellulose in combination with softening or plasticizing agents. It is interesting to note that other types of plastics can be prepared with ethylcellulose which considerably broaden the utility of the product, such as mixtures of ethylcellulose with synthetic and natural resins.

Cellulose derivatives are used in plastic products chiefly because they are tough. The toughness is a result of the fundamental structure of the material; that is, they are long chain compounds. The average molecular weight of a cellulose compound suitable for plastics is of the order of 75,000–100,000, whereas that of a resin is usually of the order of 5,000–20,000.[3] It has been calculated[4] that the force required to pull apart a cellulose chain is of the order of that required to break a piece of mild steel. This high tensile strength, combined with flexibility and elasticity, shows why the cellulose compounds have proved so valuable in plastic products.

Ethylcellulose is compatible with a wide variety of natural and synthetic resins, and these mixtures with or without plasticizers or softening agents may be compounded by mechanical methods without the use of volatile solvents. By a proper choice of resin and plasticizer, mixtures may be made which are tough, hard, resistant to water and chemicals and of good color.

The resins which are useful are those which do not polymerize at all or polymerize very slowly. Ethylcellulose will toughen resins of this nature, in some cases with the aid of a plasticizer, but when polymerizing resins are used the ethylcellulose becomes insoluble when high degrees of polymerization are reached.

In an attempt to evaluate resins for their suitability for use in plastics, a series of tests was carried out to determine the effect of different types of resins in different proportions on the physical characteristics of the mixtures. It was decided that these properties could be more readily determined on thin films applied to steel rather than on the bars ordinarily employed. Data on a few representative resins are given in Table 1.

Discoloration was determined by exposure to direct ultra-violet light and is reported as very bad, bad, moderate, slight, very slight and none. None of the compositions will be as free from discoloration by sunlight as ethylcellulose alone, which is not discolored at all. Mixtures of ethylcellulose with non-discoloring plasticizers, which represent the usual type plastics made with this product, are suitable for pastel shades and clears, whereas those made with a majority of resins would not be satisfactory for such use. However, in darker colored plastics the addition of ethylcellulose to the resin will toughen such plastics sufficiently to broaden their field of utility. The toughness at low temperature is particularly marked.

In determining the sensitivity of the various compositions to water, 5 percent hydrochloric acid and 5 percent sodium hydroxide, the compositions were applied to clean steel panels and then (*Please turn to page 124*)

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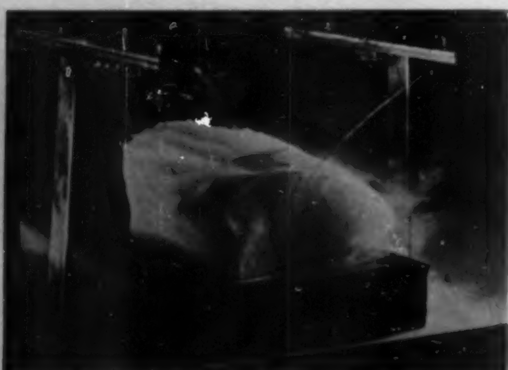

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Fig. 1—Chemist at Hercules Powder Co. Experiment Station measures viscosity in a control test. Fig. 2—Hercules demonstrates flexibility of material at low temperature by causing it to support dry ice −78.9°C. Ethylcellulose plastics, made by Dow Chemical Co. are being injection molded (Fig. 3). Ethylcellulose finds commercial application in textile inks, and is also being woven experimentally into various fabrics. Those shown (Fig. 4) are from the Zapon Division, Atlas Powder Co.



Cast resins may be sawn, turned, drilled or otherwise shaped and fabricated into finished merchandise. Typical operations may be seen above—left, cutting rods on an abrasive wheel; center, turning a rod on a turret lathe; right, pattern being cut from flat stock with a jig-saw. (Photos courtesy Catalin)

FABRICATING CAST PHENOLICS

by S. M. COAN

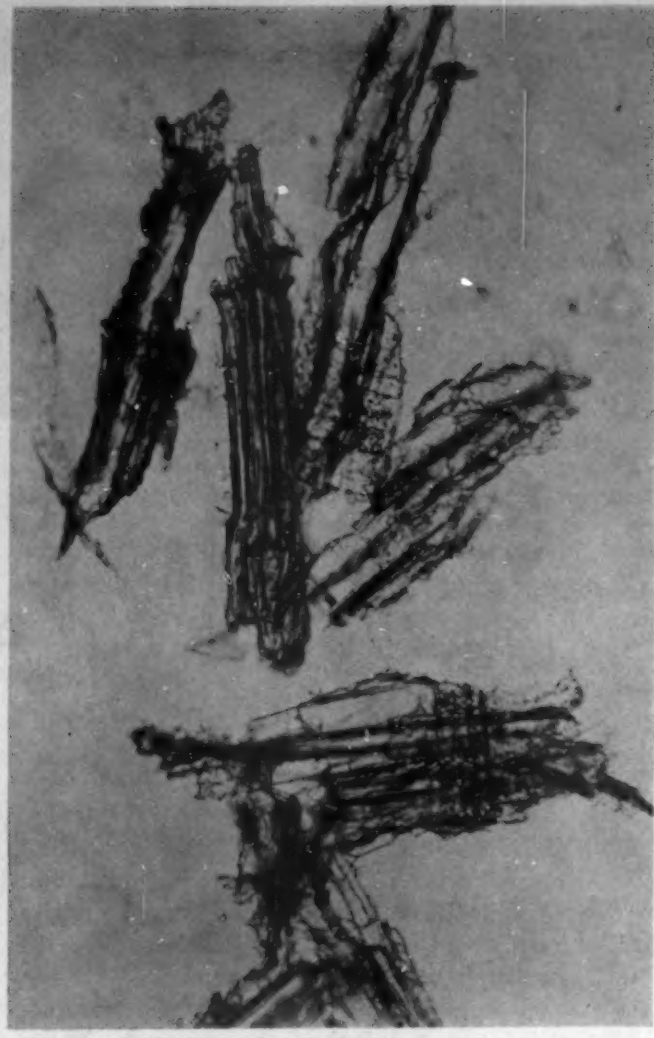
ALTHOUGH COMPRESSION MOLDING IN SOME form is almost as old as civilization, the fabrication of cast resins is a comparatively new industry, and quantity production has been developed during the past ten years.

The advantages of cast resins are numerous. Almost every imaginable color can be obtained, and the color and mottle exist throughout the material. Plain, mottled, opaque, translucent and transparent materials are available. Arbors, being simple, can be constructed within a very short time, and material requires but from four to twelve days for curing, depending on color and base. Deliveries of finished parts, can therefore, be made within less time than usually required for the production of molds used for other plastics.

A well equipped fabricating plant has departments devoted to all of the various operations, and is so laid out that articles going through production travel from machines used on initial operations to final polishing, inspection and shipment without unnecessary handling. If the parts are to be turned from solid rods, the maximum number of pieces which can be produced from an individual rod must be calculated with allowance for cutting off, flash and end of rod that is to be held in the collet when final piece is being turned. An order is placed with the raw material suppliers for the correct number of rods in color and size required, and when these rods are received and checked, it is first necessary to remove, by a fast grinding operation, any rough flash that may extend beyond the greatest diameter at end of rod, so that difficulty will not be encountered when feeding through the screw machine. Automatic screw machines are sometimes used, and have the advantage of speed and low labor cost if volume is large. Their disadvantage lies in the fact that cast rods average 20 in. in length and are tapered slightly. Unless rods are centerless ground to remove this taper, trouble is sometimes encountered with the feed. Quite often a longer piece of material must be allowed for the last part to be turned. As most runs are not over several thousand pieces of a design, hand screw machines prove satisfactory. They can be set up quickly and expensive forming tools are not required. Ball bearing centers and automatic die heads for threaded parts are almost a necessity. All forming operations, usually done on brass or other metals, can be accomplished if machines are operated at correct speed and tools are properly designed. Forming tools made of brass and of steels of various hardnesses, give good results.

Samples and small lots can be most economically turned on a hand lathe with hand tools. Hand lathe operators are usually skilled men with quite often many years' experience turning similar parts from older plastics. They make their own chucks of bronze, aluminum or wood, and can chuck and center the part to be turned in a fraction of the time required by an unskilled operator with conventional tools and equipment. In the production of bracelets, for example, it has been found advantageous to heat the cylinders for a short time by immersion in hot water. The entire cylinder is placed on a mandrel and the maximum number of bracelets that can be obtained from a cylinder can be turned before the material cools.

A combination of line shafting and unit drives is probably most economical. Some special machines must have their own motors in order to insure constant high speed and belt tension. The plant should be so arranged that failure of any one motor will not delay production more than a few minutes. Ball (*Please turn to page 142*)



PHOTOMICROGRAPHS COURTESY BAKELITE

Fig. 1.—Attrition mill grinding of woodflour X175

Fig. 2.—Hammer mill grinding of woodflour X175

FILLER REQUIREMENTS

by VIRGIL MEHARG

A YEAR AGO THE WRITER EXPLAINED HOW thermosetting compounds of the phenol-aldehyde or urea-formaldehyde types may be greatly modified by the proper choice of fillers.[1] The reasons for using fillers and the particular property which each filler enhances in a compound were described. Special property materials have thus evolved to meet a host of special uses.

The response to this article reveals that a great interest exists in the possibility of employing many other types of fillers in the plastics industry. Indeed, for years past, leading manufacturers of plastic molding materials have been besieged with requests to experiment with a great variety of fillers. These requests indicate a definite lack of information as to the requirements of a good filler. Plastic material manufacturers have welcomed opportunities to test new types of fillers but in too many instances, the results have been negative. Nevertheless, it will be brought out further in this article that there is still a field for improvement, as no perfect filler exists or seems likely to be found. It is believed that a discussion of the chief requirements of a good filler, together with some of the reasons, may aid in this search for better molding material fillers. Hence, we propose to enumerate briefly these requirements and to show why present fillers are used and wherein they excel or are deficient.

General requirements of fillers

In the following table, the requirements are divided into those considered primary and secondary. In other

[1] Modern Plastics, October 1937

words, both primary and secondary are important but in the case of the secondary requirements some compromise is possible for certain uses.

Primary requirements

1. Good strength properties—particularly impact and tensile strengths
2. Low moisture absorption
3. Low molded specific gravity
4. Easily wetted by resins and dyes
5. No effects on steel dies—chemical or physical, particularly no abrasive effects
6. Low cost and large supply

Secondary requirements

1. Good electrical characteristics
2. Light color which is retained at elevated temperatures and in the presence of resins and chemicals used
3. Inertness to acids, alkalies and solvents
4. Easy machinability
5. High in heat resistance
6. Non-flammability or low burning rate
7. Availability in controlled mesh size and bulk factor
8. Non-odorous

In addition to these requirements there will be others peculiar to the compounding methods employed. Since these will vary with the particular process used, there seems little point of going into this phase. However, compounding methods are often so important that a plant test is always necessary, preliminary to approval of a new filler or new modification.

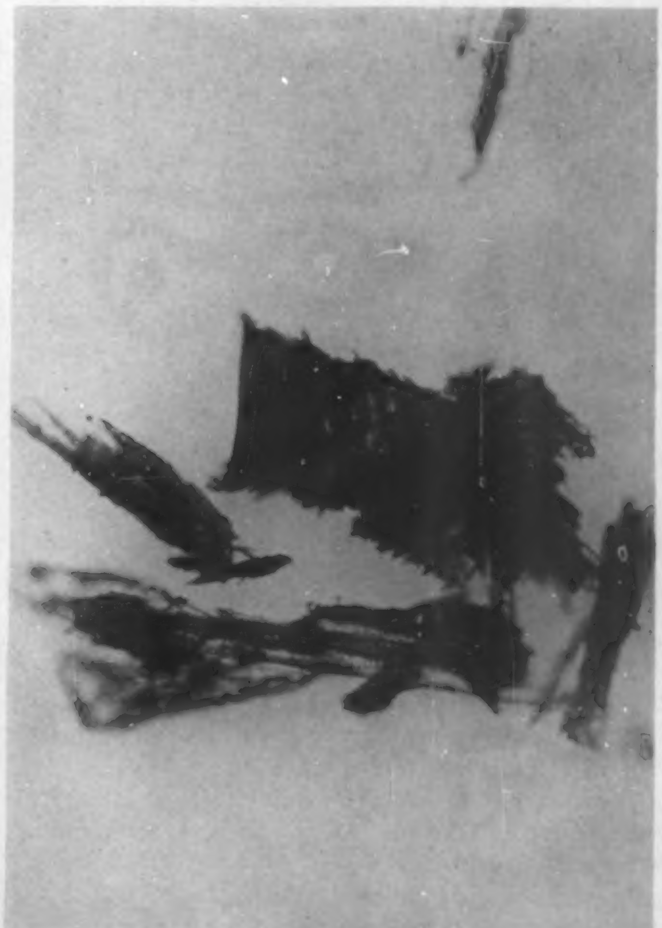
Some of the primary and secondary requirements bear further explanation:

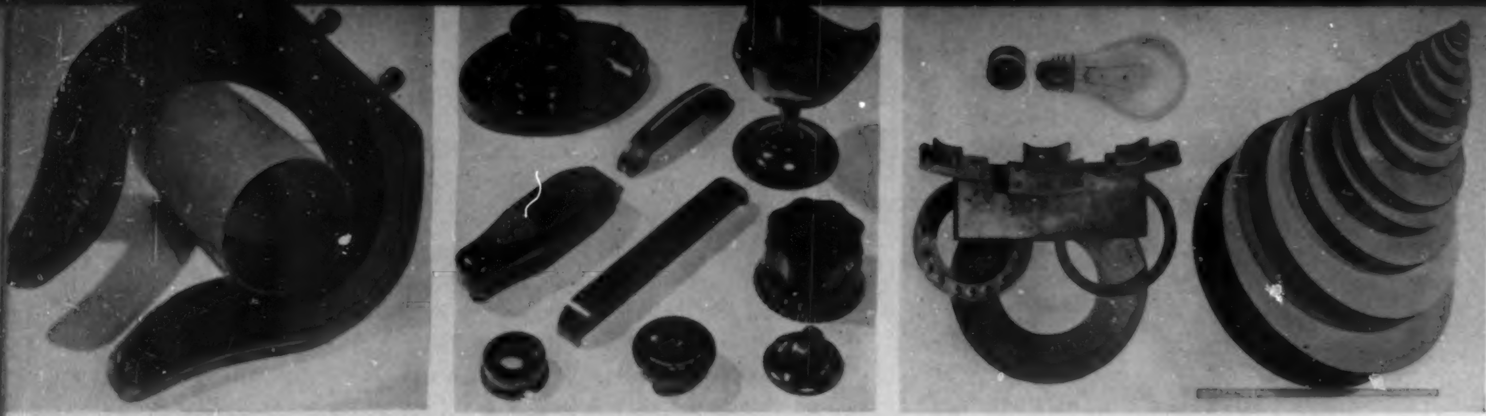
Primary requirements

The need for ***high strength*** properties is obvious. However, there seems to be a general lack of appreciation of the part played by the filler in this characteristic. Apparently in the minds of many, the resin is the bond and therefore is the main factor in imparting strength. While the strength of the resin bond is important, fillers also exert marked effects. This is particularly noticeable in ***fibrous*** types, which will be (*Please turn to page 146*)

Fig. 3.—Attrition mill grinding of woodflour ×175

Fig. 4.—Saw cut sample of woodflour ×175





Group of parts molded of furfural phenol plastics (left and center), and cold molded abrasive wheels, frictional blocks and facings (right) in which furfural phenol is used. (Photos courtesy Durite Plastics, Inc.)

FURFURAL PHENOL COMPOUNDS

by E. E. NOVOTNY

FURFURAL RESINS HAVE PROPERTIES FITTING well the needs of molding compound production and the requirements of the molders. The most important are reflected in cure and plasticity; that is, the resin and compounds become soft and plastic at low preliminary heating temperatures, with little or no polymerization, and at elevated temperatures polymerization or cure is rapid. The high molecular weight of furfural, its anhydrous nature and equal molecular combining ratio provide a resin having less molecules of phenol and of furfural to a given weight of resin and, for that matter, a relatively smaller ratio of phenol. Thus the resin is indeed unique. These unique properties become further advantageous as furfural the aldehyde is likewise an excellent solvent and resin plasticizer and finally resinifies of itself or acts as a hardening agent for the previously formed resin. It will therefore be evident that a limitless scope of plasticity or flow, of reactivity and of ratio of filler to resin may be provided inasmuch as the resin may contain more or less of furfural within its structure.

It will be seen that the resin may be liquid, semiliquid or solid, may comprise various degrees of fusibility or have various melting points and thus the distribution of resin to filler may have the widest scope of proportions. From the standpoint of reactivity or cure a resin may be made which will cure in the fractional part of a minute, and then again a resin may be provided which will cure completely within a period of fifty hours. Thus with cure time available over a wide range and plasticity that can be regulated to likewise cover a range from a liquid flow to a product of high melting point, the essential features of flow and cure may be provided to meet most diverse molding conditions.

The matter of cure and flow, however, does not represent fully all of the attributes of furfural, but furfural alone has been shown, in my previous articles,[1] to resinify progressively from the liquid to the final solid ultimate form with or without the application of external heating, and such resin alone is strong, tough, shock resistant and possesses excellent dielectric properties.

[1] October 1936 and October 1937 issues

Furfural resins for cold and hot molding processes are produced under regulated reactions whereby the products do not readily form soft coriaceous masses in the intermediate processing of the products into compounds and side reaction products, and therefore the resins remain fusible and flowable for a long period of time, the molding characteristics are retained with the advantage of long keeping qualities, and no rapid change to its cross linkage cured and ultimate form occurs until it is subjected to relatively high temperatures. The furfural resins therefore when used as a binder for various fillers are homogeneous throughout and the moldings made with these resins as binders eject from the molds clean, bright and shiny. The mold cavities take on a high luster and polish as the work progresses and the color of the pieces is brilliant. Furthermore, the lack of soft, gummy characteristics is clearly demonstrated and advantageous when the pieces are ejected from the mold at full heat, having a firm, set and rigid form of high dimensional accuracy without showing the usual soft, high deflection of many other synthetic resin compounds. Thus moldability, finish, and accuracy of dimensions can readily be controlled under a wide range of molding practice, speed, and type of filler used.

The melting points from batch to batch are maintained within close limits and the matter of introduction of fillers is simple since the product may be impregnated into sheet-like materials of paper and cloth, or various other comminuted fillers may likewise be impregnated, or the dry resin may merely be admixed with such fillers, or such admixed fillers may subsequently be compacted by being rolled for a brief period between heated differential rolls. While many of these operations can be carried out with resins of other aldehyde derivation the simplicity and uniformity of the products producible through the use of furfural resins are such that the products can readily demonstrate their superiority through actual use. As an exemplification of furfural resin moldability the manufacture of four color, fine screen color plates could be mentioned. These plates can be molded against a lead mold as the (*Please turn to page 154*)

INJECTION MOLDING

by ERNST A. GRENQUIST

BRIEFLY, INJECTION MOLDING IS THE PROCESS of molding comprising the injection of a thermoplastic material in a soft flowable condition from a heated cylinder through a nozzle into a cold or warm mold. The molding composition in form of powder or granulations of specified size is fed from a hopper into the heating cylinder of the injection machine. The heating cylinder is provided with an injection piston and a nozzle and is heated by various heating devices under exact control. When the molding material is sufficiently heated to become soft and ready to flow, the plastic mass is quickly injected into the mold cavity by a single stroke of the piston. The mold is filled almost instantly and, being at a temperature below the softening point of the material, rapidly absorbs the heat from the soft plastic causing it to harden or set so that the article can be quickly ejected from the mold. By this time a sufficient quantity of material has been softened in the heating cylinder to again fill the mold and the cycle is repeated. The rapid succession of injection of plastic material and ejection of the molded article makes possible an economic process for the mass production of a great variety of articles. The rate of production is controlled by the quantity of material injected at each stroke of the piston, the time required to render it plastic and the time required to set or harden the article in the mold for ejection.

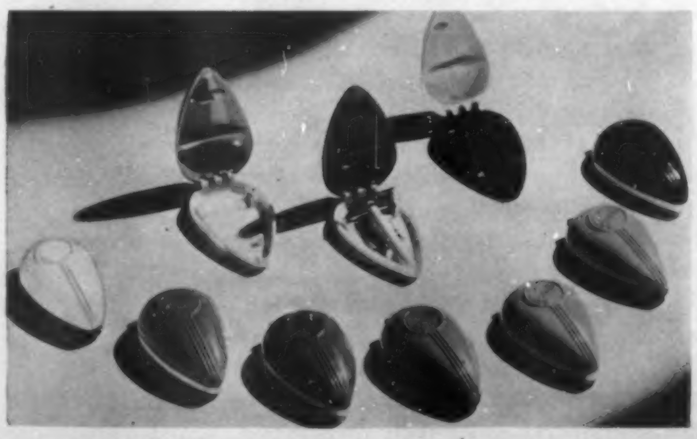
Injection Molding Machines

While machines ten years ago were hand machines or pneumatic, injecting only a few grams and providing for mold closing pressures taking care of a few square inches only, machines today claim more than 60 square inches of projected mold area and injection capacities of one pound of material or more.[1] This development is by no means completed. Machine development today is carried out along two lines; plastification of material in a single cylinder, using different methods of heating and different designs of heating cylinders, or multiple cylinder injection presses, where the plastified material required is obtained by simultaneous injection into the mold from several injection units. The mold closing is taken care of by toggle or wedge-clamping or direct hydraulic following pressure. (Further explained elsewhere in this issue.—*Editor.*)

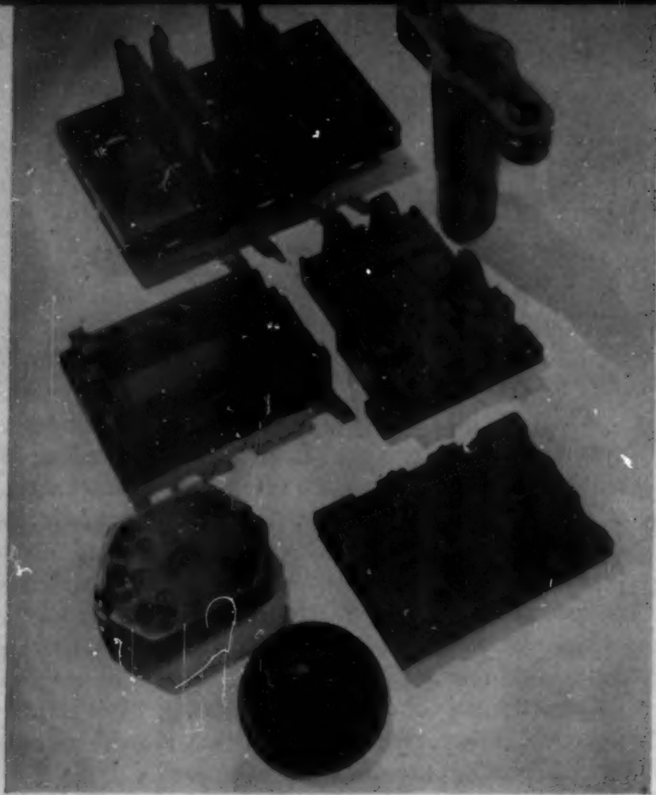
Molding Materials

There are several types of thermoplastic products that lend themselves to injection molding. The most important available today are cellulose acetate, polystyrol, vinyl resins, acrylic resins, ethylcellulose and benzylcellulose. The choice of material (*Please turn to page 160*)

[1] Written in June 1938.



The Lumarith boxes (at the left) house tiny Razorettes, under-arm razors for feminine use. They are made by St. Claire Mfg. Co. The automobile hardware (lower left) is molded in 12 to 24 impression molds in cycles of 20 seconds using Lumarith. Thousands of combs are injection molded daily in dozens of plastics. Those below are of Plastacele in clear crystal, clear amber, opaque white and tortoise shell color. One has a spring clip which holds it securely in a man's pocket



Cold moldings find their greatest use in the electrical industry because of their dielectric properties. Those at the left are from the General Electric Co.; those at the right, from American Insulator Company

ORGANIC COLD MOLDING

by EMILE HEMMING

THE WORD PLASTICS IS BY NO MEANS NEW, BUT during the past thirty years it has become associated in the minds of many with materials which prior to 1908 were unknown. Before that time, plastics generally referred to celluloid, rubber, shellac and other similar materials often called shellac compounds, molded insulation and such. Finished products were made by melting the materials in heated molds, cooling them under pressure, then removing for final finishing or for use. In the case of rubber, this process is called vulcanizing.

None of these products with the exception of those made with rubber were heat resisting after molding. They were thermoplastic materials; that is, the same degree of heat used for molding would soften the products again after molding. Because such products were incapable of resisting heat—even boiling water temperature would soften them—they were naturally limited in their applications and the electrical industry was forced to rely upon porcelain (which was fragile), treated wood, metal with fiber, porcelain or mica combinations, for insulation. Those who have seen the exhibit of Thomas A. Edison's inventions, especially his first electric lamp, will realize that the lack of proper plastic products at that time constituted one of his greatest handicaps.

These conditions then existing in 1908 provided a wide open market for the advent of commercial molded plastic products which would not soften after molding and two distinctly different products appeared in the United States during that year. Both were heat resisting but were made under entirely different processes and with different basic raw materials.

One product, phenol-formaldehyde, introduced by Dr. Baekeland and detailed elsewhere in this issue, followed the conventional hot molding methods, but through polymerization (heat-hardening) became an infusible product which would not soften after molding.

The other product, which generally speaking has even greater heat resistance, was introduced by the writer and became known as Organic Cold Molding. Neither the process nor the organic cold molding materials have been as widely publicized as phenolics because, unlike them, the materials are not manufactured for general distribution. Instead, those molders who operate the cold molding process make their own materials and brand them with their own trade names.

Organic cold molding materials

The basic materials used for the cold molding process are asbestos, asphalts, coal tar, stearin pitches and resins of natural organic origin. The asbestos (proportion 70 to 80 percent) constitutes the body of the material and the asphalts (20 to 30 percent) the binder.

The asphalts, pitch or organic resin is brought into solution by suitable solvents. (*Please turn to page 164*)

The author of this article introduced and pioneered the Organic Cold Molding industry in this country, wrote a book on the subject in 1923, now heads a hot molding company; does no cold molding—*Editor*.

PHENOLIC RESINS FOR PAINT AND VARNISH

by CHARLES T. O'CONNOR

SHORTLY MORE THAN A DECADE AGO THERE was announced a perfected resin in which an organic chemical had been added to a phenolic resin to make it disperse in oil before it had a chance to "set up." This is still on the market and is a real milestone in the progress of phenolic resins in the paint and varnish industry. It yields extremely fast drying varnishes that have excellent chemical resistance, hardness, gloss and durability.

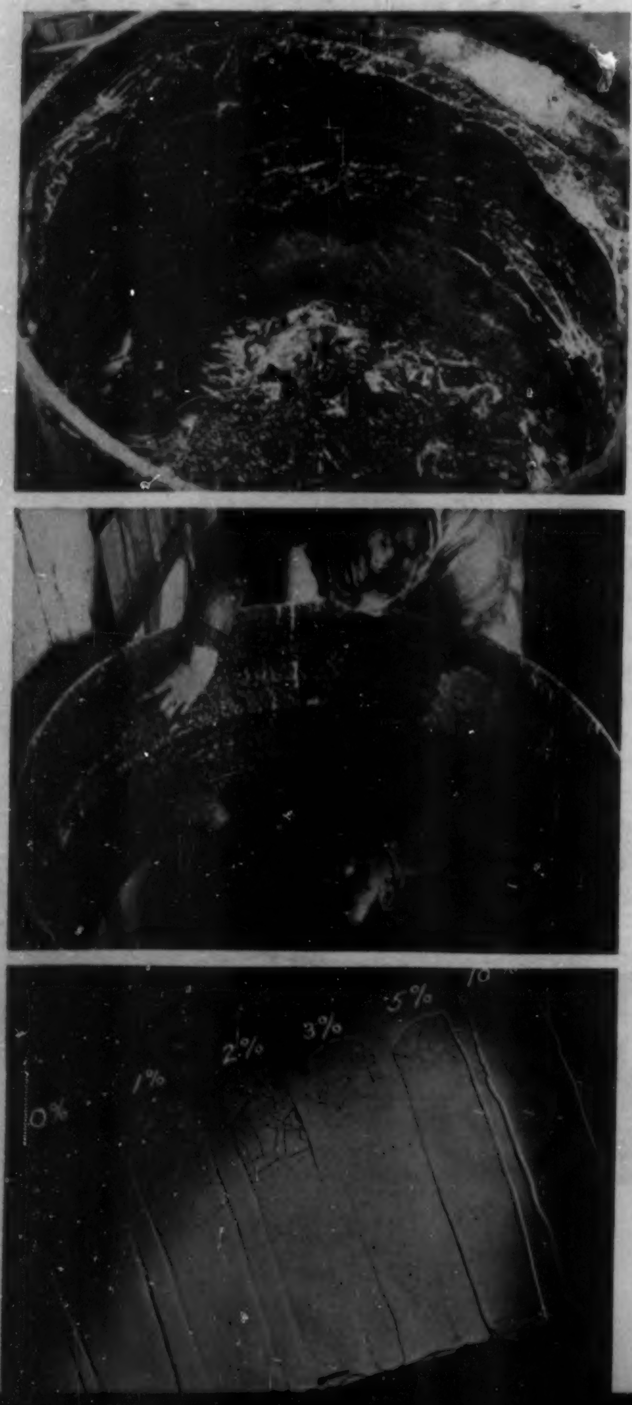
In 1931 a pure phenol-formaldehyde resin that was inherently soluble in drying oils was produced. This required no rosin nor chemical flux. It would not burn or "set up" on the bottom of the kettle. There was no organic flux to boil off if localized heating occurred. All of the properties characteristic of phenolic molding compounds such as durability, gloss and chemical resistance were held in this oil soluble resin. It chemically reacts with Tung oil which has long been a bugaboo to the paint manufacturer because of its skinning tendency, and because it crystallizes on drying and leaves a flat, dead looking finish in spots. Both these difficulties have been overcome with the advent of this new oil soluble, phenolic resin. The photographs show a tank of varnish cooked without the phenolic resin revealing excessive "skinning," and a tank cooked with the resin showing the clear, mirror-like surface that is absolutely skinless.

However, all the resins developed thus far had one common fault. They turned slightly yellow either during the drying of a varnish or enamel, or during a period of exposure to sunlight. In their continuous search for improvement chemists of the phenolic resin group have finally formulated a new resin which has overcome this "yellowing" property. Today there is a marketed oil soluble resin which has all the characteristics of these first resins plus the ability to deliver gleaming white enamels which really stay white.

With these fine tools at his command the paint and varnish maker still finds that he is compelled to manufacture for three markets: those who want just plain coverage; those who want a good paint or enamel at an average price; those who want the finest obtainable in surface protection regardless of cost. He can satisfy the first group by using natural resins, like rosin, and he can take care of the latter class by using pure phenolic resins, but for the middle class he has to arbitrate. He must dilute these potent phenolic resins with other resins until he can afford to sell his product at an attractive price and still retain as many of the good points of the high quality goods as possible. So he asks of the resin manufacturer, "How much 100 percent phenolic resin should I use in my paint or enamel?"

To answer this question it is necessary to know what the paint man is trying to make or if he has a material that is deficient in one property, how much does he want to improve it—which is limited by what he can afford to pay without increasing his selling price. So one manufacturer goes about the problem in the following ways:

If the varnish is not gasproof, that is, if it has a tendency to dull down when (*Please turn to page 40*)



A tank of varnish cooked without phenolic resin (above) and a tank cooked with the resin (below) show the absence of "skinning" when the resin is used. The bottom photo shows how "alligatoring" in an ester gum resin was overcome by the addition of 10 percent pure phenolic resin. (Photos courtesy General Plastics, Incorporated)

X MARKS THE SPOT
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But X, remember, also indicates the unknown quantity!

The "first time" plastics user may choose the molder's shingle which offers him the lowest price. Does it matter whether it operates on a "hot dog stand" basis, with a second-hand press or two, or is liable to fold up at the first sign of tough going? Is there much loss entailed?

The experienced plastics user knows that there is no substitute for a reputable molder . . . with adequate experience and equipment, and a progressive personnel. He knows that economies in this business result from production efficiency, and in finding the shortest route from blue print to product . . . *and in no other way!*

We of Boonton know of no better advice to give you who are first, or newly, contemplating plastics—and we can't make it too strong—than

LOOK BEHIND THE CONTRACT TO THE PLANT THAT MAKES THE PRODUCT!!

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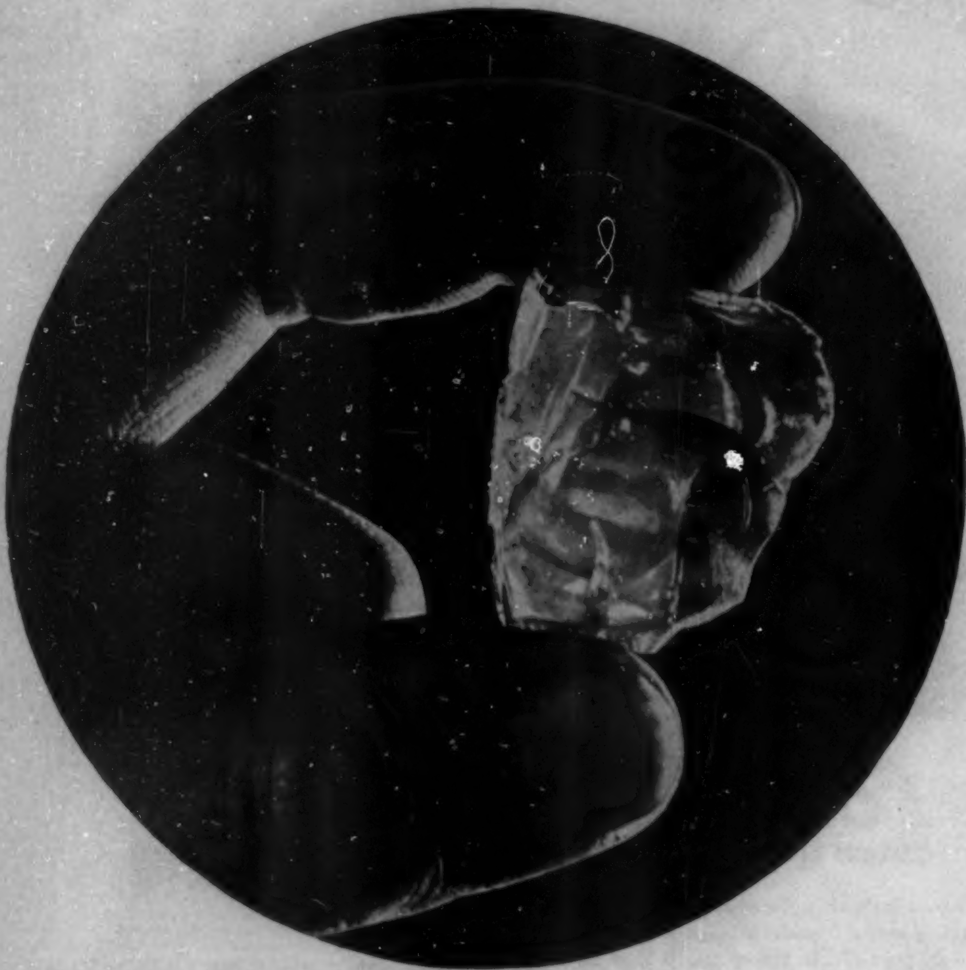


DUREZ resins have countless uses in . . .

AUTOMOTIVE, COMMUNICATION, BUILDING, ELECTRICAL, PAINT

AND MANY OTHER FIELDS

WHAT ARE THESE RESINS?

They're synthetic or artificial gums built up from chemicals. Durez resins are phenol-formaldehyde derivatives which set infusibly by chemical reaction —not mere oxidation. They are used for such diverse purposes as bonding metal to wood or rubber; impregnating pulp, fabrics, asbestos; protective coatings for wire, metal, rubber, wood, composition; for insulating, sizing, bonding, acid and waterproofing.

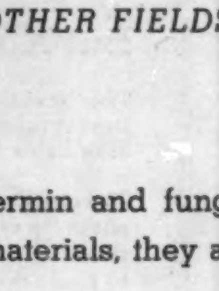
WHAT DO THEY DO?

The jobs that a Durez resin can do are almost unlimited. Used to impregnate brake linings they lengthen life, end squeaks. They waterproof paper and cardboard containers. They are used to impregnate noiseless, long-wearing fabric gears. To plywoods they impart resistance to moisture, vermin and fungus growth. Applied to a variety of materials, they add

RESISTANCE TO

SOLVENTS	FRICTIONAL WEAR
OIL	HEAT
GREASE	ACIDS
CAUSTICS	ELECTRICITY

There are over 100 Durez resins, each designed for a specific use. In our many years of research and experiment we have accumu-lated data on a wide variety of applications. Feel free to write u in complete confidence so that our experience and yours may b combined to mutual advantage. Our laboratory staff is ready t cooperate on specific applications involving synthetic phenolic resins. In writing, give as much information as possible. Address General Plastics, Inc., 210 E. Walck Road, North Tonawanda, N. Y.



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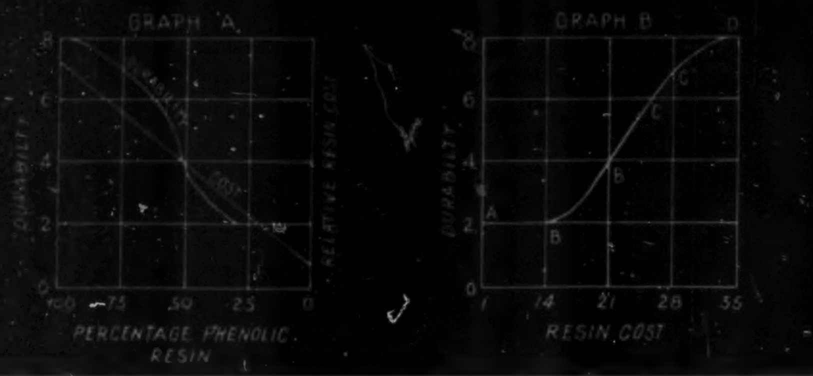

PHENOLIC RESINS FOR PAINT AND VARNISH

(*Continued from page 36*) used in homes which burn natural gas, he recommends the use of small quantities of this special resin. It may be added directly to the varnish as it is being made without any change in procedure. It is so potent in its action on the Tung oil that a varnish made with the pure phenolic resin may be cold-blended with a varnish that is giving trouble and the effect will be the same as if the resin were cooked in.

The picture shows the effect of this resin on an ester gum varnish which showed "alligatoring." This is a surface configuration which forms on a varnish or enamel during drying and which indicates under cooked Tung oil as does dulling or frosting. When the amount of phenolic resin is increased the trouble is gradually eliminated until at 10 percent phenolic resin content he will have a varnish which will dry to a clear, glossy film even in the worst of gas conditions.

Suppose the varnish skins badly. A conservative estimate indicates that many varnish manufacturers have a loss from skins in storage tanks of over fifty gallons per thousand gallons per year. Besides this, strainers get plugged, weighing machines are shut down and losses in time from inoperative machinery rise rapidly. There is also considerable hazard from fumes in cleaning storage tanks of skins. It has been found that as little as 10 percent to 15 percent of phenolic resin will completely eliminate this difficulty.

As in the case of remedying the gas checking, so in stopping skinning, the phenolic resin is effective whether it is cooked into the varnish or whether it is cold-blended from another varnish. If cold-blending is used, 2 percent to 4 percent more of the phenolic resin is required. A varnish film may have very high gloss shortly after it is applied but many varnishes lose that high luster shortly after they are applied. The ultra-violet light in sunlight is particularly destructive to gloss, and soap and water will kill the gloss on many others.

The lasting full gloss imparted by pure phenolic resins may be passed on to a varnish by incorporating these resins in a varnish containing other resins. When using less than 10 percent of the phenolic resin its effect is practically covered up by the other resins and any improvement in gloss retention is questionable. Above 10 percent, however, the action is very marked and the gloss retention seems to improve directly in proportion to the amount of phenolic resin used.

The "build-up" in initial gloss due to the addition of phenolic resin varies materially with different pigments and the quantity necessary to give proper coverage to an enamel, so that it is rather difficult to give any figures on the effect of the phenolic resin on initial gloss of pigmented goods. The paint man recognizes what he calls "fullness" or "depth of gloss" that is imparted by a phenolic resin. In some cases this has been the prime mover in causing him to use some 100 percent phenolic resin in his product.

The varnish maker has a value which he calls *Kauri Reduction Value*. It is the amount, expressed in percent, of a Kauri gum solution which can be added to a varnish before the mixture becomes too brittle to bend sharply without cracking. The test is made after a film of the blend has been baked for five hours. The *Kauri Reduction Value* has been found to be practically an exact measure of durability. This is a rigid test and some varnishes show zero percent. In other words, they become so brittle by themselves while they are being baked that they crack when they are bent. Spar varnishes made from natural resins may fail at 75 percent to 100 percent but a spar from certain phenolic resins will run as high as 185–190 percent and a new resin recently tested will go as high as 235 percent.

Since the *Kauri Reduction Value* is a measure of durability, it can be determined approximately how much phenolic resin the varnish man should use in various classes of items by consulting a curve of Durability vs. Phenolic Content published in the trade journal *Paint, Oil and Chemical Review*, January 1937.

We have superimposed a cost curve on the durability curve in Graph *A*, and in Graph *B* we have plotted a composite curve. From point *A* to point *B* the paint manufacturer gets increased gloss, a decrease in skinning tendency and gasproofness but he accomplishes little that is definite in increased durability. From point *B* to point *B'* he begins to realize an increase in durability. From point *B'* to point *C* he realizes a definite return in durability on every additional pound of phenolic resin he uses in the formula. In this range we find the phenolic content of a good grade of spar varnish. From point *C* through *C'* to *D* we see the law of diminishing returns cut down the rate of increase and it begins to cost real money for greater durability. Here we are in the range of "Super Spars."

The paint and varnish manufacturer has a powerful tool in the 100 percent phenolic resins. They are pure—not contaminated with stones, dirt, twigs, leaves, etc., as are fossil gums. They are uniform pound after pound, ton after ton, year after year. He knows just where he stands; just what he can do to correct practically any difficulty that arises in his plant.

. . . since 1931, when we molded the first plastic cabinets for Kadette radios, no custom molder has produced more cabinets, nor better ones. That is why such leading firms as Zenith, Crosley, Sparks-Withington, Majestic, Radio Products, Wells-Gardner, Detrola, Colonial, International, and a host of others are today among our customers.

Still, we do not specialize in radio cabinets. In every other industry using plastics—electrical, scientific, automotive, and so on—the list of Chicago Molded customers is equally impressive. For the same factors which have made us leaders in serving the radio industry, have made us leaders in serving ALL industry —ample production facilities, unsurpassed engineering skill, broad experience, and above all, an intelligent appreciation of our customers' needs.

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PHENOLICS—BACKBONE OF THE INDUSTRY

by DON MASSON

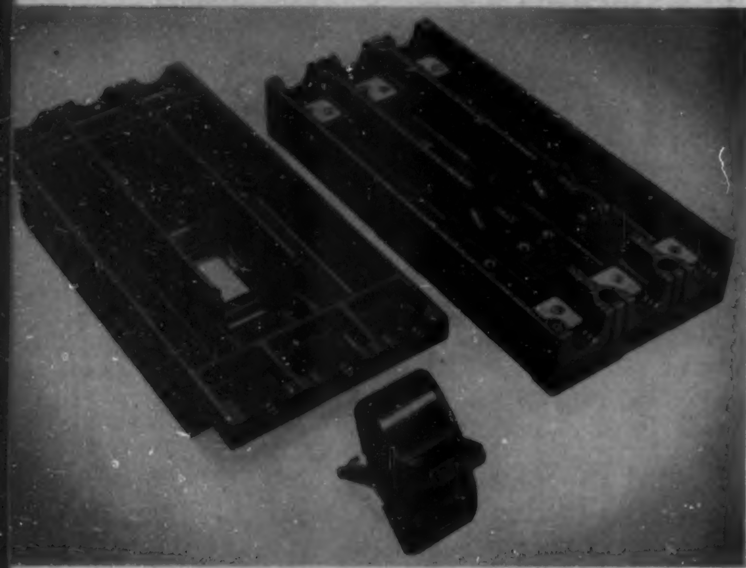
THAT PHENOLICS ENJOY NUMBER ONE POSITION in our modern plastics industry, and that they find their way into every branch of American business cannot be accredited solely to the fact that they are lower in price than other synthetic plastic materials. Their low prices may be attributed in part to their constantly increasing use and also to the availability of raw materials employed in their manufacture. But, what accounts for this widespread use of phenolics? It is due to the *combination of many desirable properties* and the characteristics which are to be found only in phenolic resinous plastics. This combination of properties remains supreme.

By no means should we overlook the virtues of the newer plastics—the polystyrenes, the ureas, the cellulose acetates, the vinyl resins, *et al*. These plastic materials play a definite part in this ever-growing industry. Each has one or more advantages that may not be found in the others, and even in the phenolics. The purpose of this article, however, is to clarify for the user of plastics why phenolics remain first because of their unique combination of properties and characteristics.

What are these properties required in plastic molding materials? How do phenolic plastics fulfill the demands of industry to serve the American consumer with dependable manufactured products? The major property demands by industry of molded plastics are: dimensional stability, heat resistance, water resistance, mold shrinkage, ability to mold pieces of thick section, hardness, freedom from cold flow, and moldability.

Dimensional stability

This property is considered the ability of a material to maintain its original dimensions under actual usage.



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Typical phenolic moldings are: circuit breaker with thick sections (1); mechanical parts with predictable shrinkage (2). Both are Bakelite. Automotive parts (3) and precision molding (4) with dimensional stability. Both are Durez. Salt tablet dispenser (5) of Resinox

4

5

In the past twenty-nine years a vast amount of information has been collated on the relative dimensional stability of the wide range of phenolic materials. Industry knows what to expect in regard to pieces molded from them. From commercial applications it is known that any slight change which takes place in phenolic molded parts is not sufficient to give serious trouble on a large number of uses where maintenance of accurate dimensions is essential. Automobile ignition rotors, distributor heads, motor housings, commutators, and many similar applications bear out this fact. With the possible exception of polystyrene no other plastics have proved to be as stable in dimensions after molding as the phenolic materials. On the other hand, polystyrene withstands temperatures only to about 175 deg. F.

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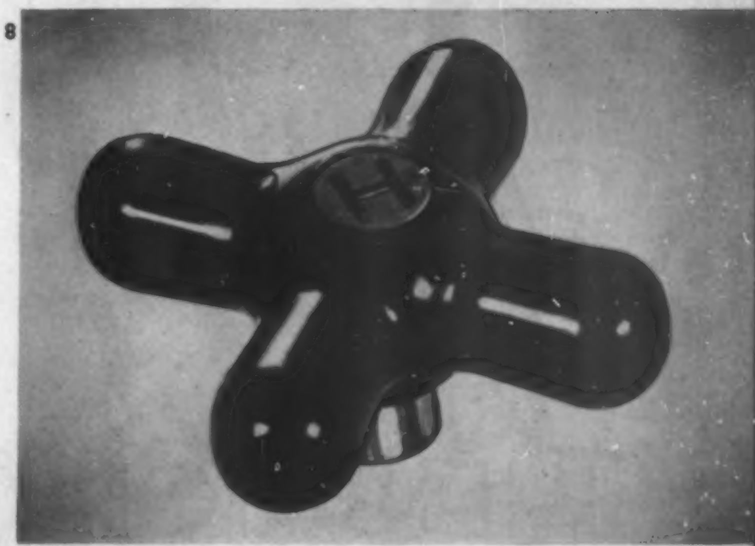
Heat resistance

There are many applications where heat resistance is an important factor. "Cold mold" plastics have proved exceptionally well suited in this field, but again the combination of properties inherent in phenolics makes them far superior for many heat resistant uses. Even the general purpose cellulose-filled phenolics withstand higher temperatures than other types of plastic materials with the exception of "cold molded," and of course there are the special high heat resistant mineral-filled phenolics which will withstand temperatures as high as 450 deg. F. Therefore, such products as heater plugs, cooking utensil handles, and permanent wave machine parts continue to be made of phenolic materials.

Water resistance

This property is also important for many applications. Where there is an extremely humid condition and the part must maintain its luster and strength, there is generally a phenolic material which will meet these requirements after all other phenolics have failed. In water resistance phenolic materials surpass all others with the exception of polystyrene.

8



Shrinkage

The phenolic plastics produce parts with a more predictable shrinkage than (*Please turn to page 46*)

Electric irons (6) become practical with phenolic handles which resist heat; shampoo trays of phenolic (7) resist chemicals and moisture; threaded parts of phenolic (9) fit well because there is no cold flow. (Photos courtesy Bakelite Corp.) Hot and cold water faucet handles (8) are being molded of phenolics which are less fragile than porcelain, less expensive than brass. (Photo courtesy Resinox Corp.)

9

10

11

Phenolics are equally suited to decorative uses when dark colors will suffice as evidenced by this Emerson radio (10) of Durez. The circuit breaker (11) requires both strength and dependable insulation which phenolics provide while the rear axle bushing (12) is made of a special impact resisting Bakelite molded

12

PHENOLICS—BACKBONE OF THE INDUSTRY

(*Continued from page 43*) any others. This means that the molder can control dimensions more accurately, and therefore, if the user of plastic parts has a situation where dimensions must be maintained as the parts are taken from the mold, he turns to phenolics.

Pieces with thick section

When it becomes necessary to produce molded parts with thick sections—one quarter of an inch in thickness or greater—phenolic plastics are preferred. They insure uniform polymerization with a consequent uniformity in the finished parts.

Hardness

The surface hardness of a phenolic molded piece is definitely better when compared with parts produced from other plastics. Thus, such applications as football shoe cleats, automobile door bumper shoes, pump vanes, cams of all sorts, silent gears, and many others are possible and highly practical. Frequently, graphite is included in the phenolic molding material to reduce coefficient of friction, or fabric is incorporated as the filler to give resilience and long wear.

Freedom from cold flow

Here is another property which has made phenolics popular for many uses. Where an assembly or contact in a molded part is made by means of taking up on the nuts or screws, the manufacturer can rest assured that there will be no cold flow with the proper type of phenolic material.

Moldability

From these plastics it is possible to produce molded parts in a greater variety of sizes. Perhaps this property alone accounts for the universal consideration of phenolics.

The statement has been made in these pages many times before that there are several hundred types of phenolics. Perhaps the reader asks, "Why?" The answer is, of course, that each has been developed to meet a special condition of use. It may be chemical resistance, impact resistance, high dielectric strength, or mechanical strength.

In closing, emphasis should be made on the fact that phenolic plastics are by no means the cure-all for the plastics industry. True, they have numerous advantages, but they also have their limitations. For example, the rigidity of phenolics is a virtue for many applications and a drawback for others. Color often becomes a deciding factor in consumer preference. The phenolics yield a rich depth of luster in black and the dark colors such as brown, mahogany and walnut. Phenolics are also produced in yellow, red, green, and purple, yet they tend to darken and fade upon exposure to sunlight. For the lighter pastel shades, transparent and translucent effects, and water-white, other plastics must be employed.

POLYSTYRENE

by DONALD L. GIBB

THE BIOGRAPHY OF ANY FAMOUS CHARACTER would be incomplete unless some facts were related describing his antecedents, nor would the life history of polystyrene be complete without at least a brief description of its chemically similar parent, styrene. This is doubly true since the behavior of the child is so closely related to the characteristics of the parent. In like manner, the properties and behavior of polystyrene are greatly influenced by the purity of the styrene from which it is made.

Synthetic organic chemistry is 110 years old, having had its beginning in 1828. Only eleven years later, nearly 100 years ago, styrene was first produced in a laboratory way; hence it was one of the early organic compounds to be synthesized. Styrene itself is a transparent, colorless, mobile liquid with a characteristic odor, having a boiling point of about 145 deg. C. and a specific gravity slightly lower than that of water, 0.9035. Chemically it is represented by the formula $C_6H_5CH=CH_2$. If permitted to remain in the light, or in the presence of certain catalysts, or when heated, styrene thickens, becomes syrupy, and finally polymerizes into a hard transparent thermoplastic resin.

"But wait a minute," says the molder, "what do these chemists mean by polymerization, and what are polymers?" A good question. Glance back at the formula for styrene and note those two dashes. To the chemist they represent a "double bond" between carbon atoms; actually they signify an extra hand not required for holding the parts of the compound together. Under proper conditions this extra hand will grasp another element or group of elements and join them to the original compound. In the case of styrene, if conditions are favorable, these hands will grasp other styrene groups until they are held together in long chains, and the smallest unattached group is no longer a single styrene molecule but rather a chain of them. No longer is it styrene. It is *many* styrene, or *poly* styrene. Therefore, it is not difficult to conceive why, as this process goes on, the mobility of the original small unit compound is gradually lost, and the resulting polymer is a resinous material.

If the styrene is pure and polymerization carried out under conditions such that the process goes on slowly, the resulting polystyrene will differ greatly in physical properties from that made by rapid polymerization.

Rapid polymerization usually results in many short chains, while slower polymerization gives fewer but longer chains, and the two types of polymers, while quite similar to the eye, will differ in solution viscosity, and in strength when molded.

But let us get back to the development of styrene. The original work did not disclose that the liquid slowly changed to a resin, but, from what is now known of its habits, this must have surely taken place. We are undoubtedly correct in guessing that the styrene produced in those early days of synthetic organic chemistry remained on the laboratory shelves for extended periods of time and gradually thickened and hardened into the first synthetic organic plastic.

It was not until 1845 that styrene and polystyrene were first clearly described by Blythe and Hoffman. The process for making styrene from ethyl benzene came later in 1869 from the fruitful laboratory of that famous French chemist, Berthelot. (*Please turn to page 53*)

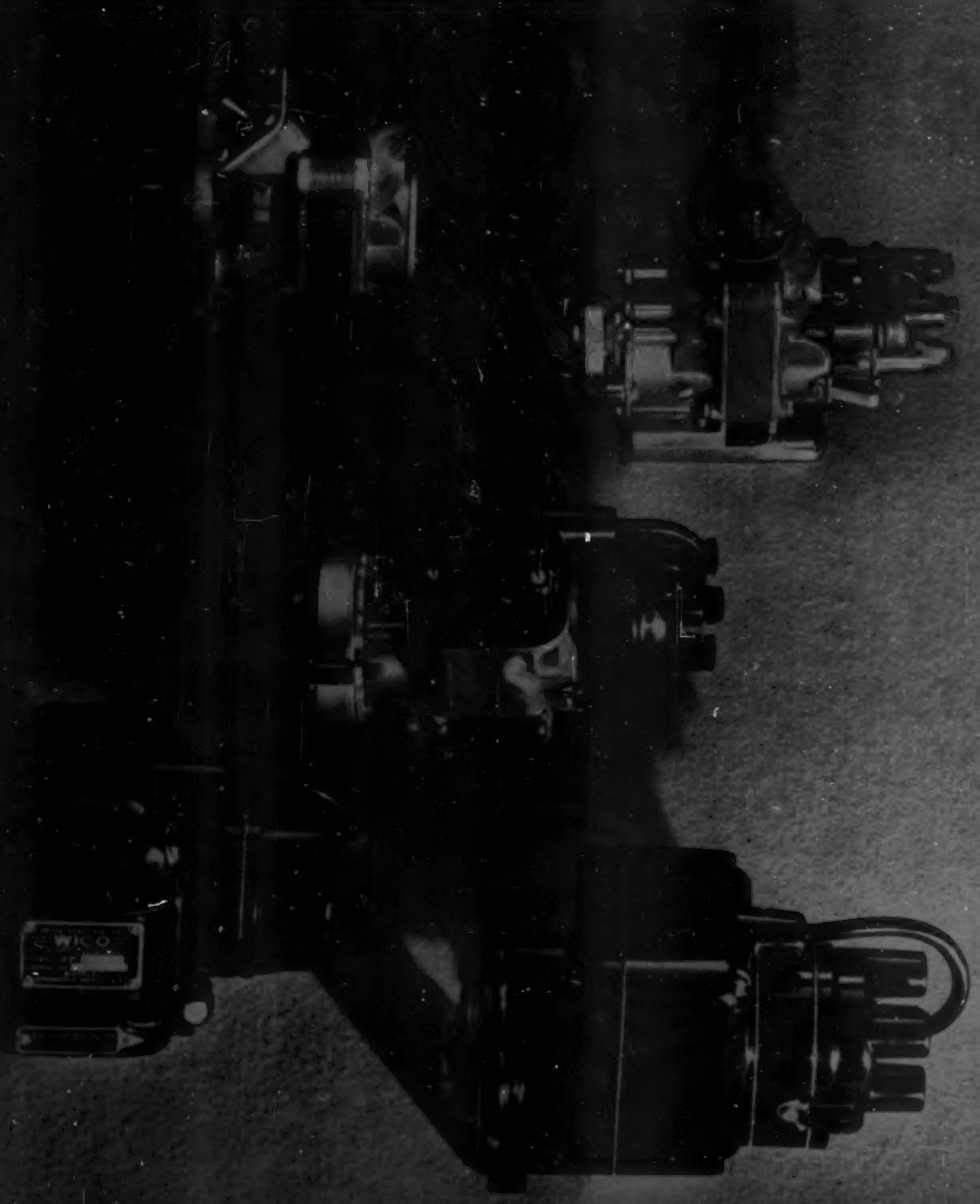
(PHOTOS COURTESY BAKELITE CORP.)

Polystyrene molding compound is clear and transparent, may be fabricated by compression or injection molding, and has excellent resistance to alcohol, water; in fact, any moisture. It is available in colors, too

Condenser Housing—the first of 22 parts molded exclusively of G-E Textolite for Wico Electric.

"AND you can see for yourself the progress in simplicity, economy and appearance we have accomplished during the past three years by combining our knowledge of magnetos with General Electric's knowledge of plastic molding.

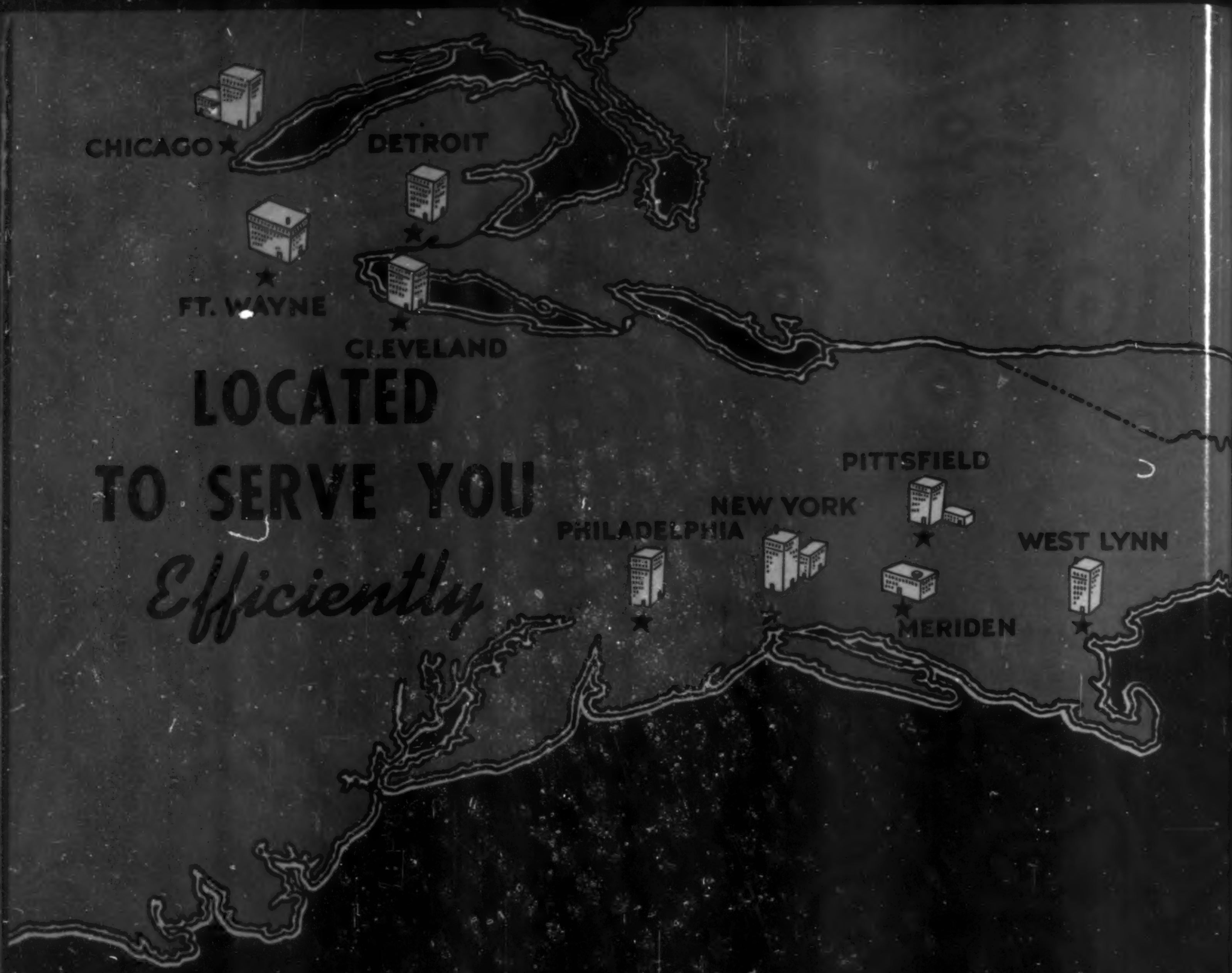
"General Electric does not let us, nor do we want to, design a part that is not a good job to mold. Such co-operation keeps our costs down and helps us to make a better industrial magneto for less money."



NOT only this statement of Mr. K. A. Harmon, Vice President of the Wico Electric Company, but the fact that the Wico Electric Company has relied on G. E. for three years for all its new molded parts, is a high tribute to General Electric's molding ability.

It bears out General Electric's belief that not only does successful and economical molding depend on an efficient engineering, designing, and manufacturing personnel, but that it is the molder's duty to guide the customer as to the design of parts to be molded so that he will derive the greatest benefit.

Whether it's MacKenzie, Milne, or any of the other G-E plastic engineers, you can depend on them for help in assuring the maximum of satisfaction from the Textolite parts you buy.


CHICAGO
DETROIT
FT. WAYNE
CLEVELAND
LOCATED
TO SERVE YOU
Efficiently
PITTSFIELD
NEW YORK
PHILADELPHIA
WEST LYNN
MERIDEN

POLYSTYRENE

(*Continued from page 48*)

Apparently commercial possibilities of polystyrene were first envisioned in 1900 by Kronstein.[1] He discovered that styrene may be polymerized to form "organic glass" and also mentioned the preparation of varnishes prepared from mixtures comprising polystyrene. In 1911 Dr. F. E. Matthews of London took out two important patents disclosing many uses which this plastic could be made to serve.[2] Dr. Matthews, after describing in his patent applications the general behavior of polystyrene goes on to say:

"The polymerized compound described has excellent insulating properties, and can for example be used in place of hard rubber, celluloid, ebonite, vulcanite, wood, glass, or the like for the manufacture of various articles; for instance, it may be used in making golf balls or portions thereof. When mixed with rubber it gives hardness and toughness to a degree in proportion with the proportion added, and from such mixture motor car tires for instance can be made which will stand high temperatures and hard wear."

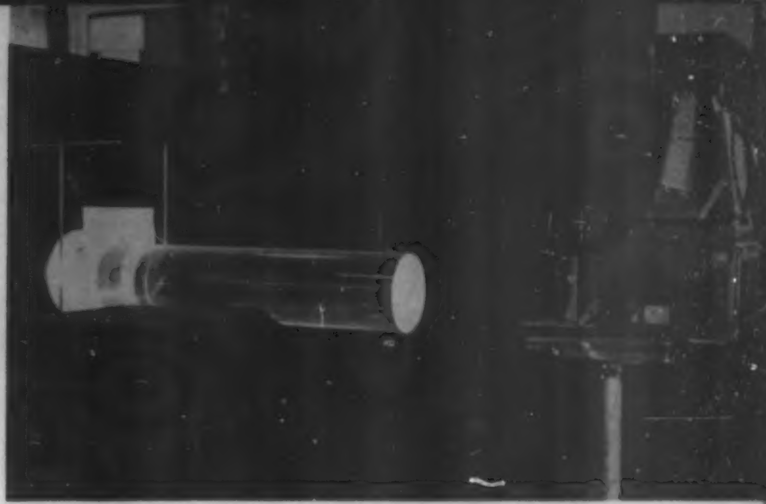
From 1911 until the present, both styrene and polystyrene have enjoyed frequent mention in scientific and patent literature. In 1922 an important contribution to the general development was made by Dufrai and Moreau, who described agents which would retard or prevent polymerization of styrene, and thus made it possible to ship the liquid to points remote from its origin, there to be redistilled and polymerized.

The outstanding favorable characteristics of polystyrene such as its clarity, hardness, low moisture absorption, high heat distortion temperature, and extremely low power factor had long been of interest to plastic users, but its high cost and its tendency to craze and blush had discouraged any wide application. For these reasons, other plastics of lower cost and having less interesting, though better understood, properties soon dominated the plastic field. It was not until the advanced development of radio and television began to demand an easily molded material of very low loss and power factors, and the packaging industry developed the present strong interest in transparent materials, that sufficient impetus was given the study of polystyrene to overcome the former objections to its use.

Years of costly and painstaking research have been required to develop methods which permit production of polystyrene at reasonable cost and of such high purity that its permanence is assured. The crystal clarity of polystyrene today is a visible sign of the purity of its chemical make-up, and its development constitutes an interesting volume in the annals of the plastics industry.

The properties and uses of polystyrene have been described in earlier issues of this journal;[3] hence the author has not discussed these matters, but has confined himself to relating a few of the high spots in the life story of this "oldest synthetic organic plastic."

(1) British Patent 17,378—1901.
(2) British Patents 16,277 and 16,278—1911.
(3) Volume 14, No. 2, October, 1936.



The Dow Chemical Co. demonstrates the clarity of its polystyrene by casting a 24-inch rod, then photographing type through the end without distorting the letters. Both the process and result are shown above

Norton Laboratories, Inc., molded this candy box from polystyrene. It has the transparency of glass with less than half its weight and is far less fragile. Looks good for packaging things to sell

Two views of the new vinyl acetal resin plant of the du Pont Company at Arlington, N. J. Left—Exterior. Right—Solvent recovery stills, one of the steps in the process of manufacture of a new acetal resin

POLYVINYL ACETALS

by A. F. RANDOLPH

COMPARATIVELY RECENT ADDITIONS TO THE list of commercial synthetic resins and plastics are those known as the polyvinyl acetals.[1,2] Their outstanding characteristic, perhaps, is toughness—a most desirable characteristic for a plastic. But while sharing this merit the individual members of the group exhibit considerable differences in some other characteristics and may be expected to follow somewhat divergent lines of commercial application.

This group of resins constitutes an excellent example of what Ellis[3] has felicitously termed "tailored molecules." Within reasonable limitations, they may be cut to various patterns of properties by appropriate selection of reagents and of conditions of reaction. To get an idea how this tailoring is done, it is necessary to visualize the rather simple chemistry of the formation of these resins. The chart herewith (Fig. 1) should help to make this clear.

The starting material is vinyl acetate, a mobile liquid of rather pungent odor, derived from acetylene. Other esters of vinyl alcohol could be used, but vinyl acetate is readily available and comparatively cheap. By virtue of the double bond in its carbon chain, vinyl acetate is capable of polymerizing; a multitude of vinyl acetate molecules join hands, as it were, to form a long chain constituting the macromolecule of polyvinyl acetate, of which the chart shows a mere fragment made up of four molecules of vinyl acetate.

The chain structure $—CH—CH_2—CH—CH_2—$ established at this point[4] is retained through the subsequent reactions, which serve merely to change the chemical groups attached to the alternate carbon atoms of this chain. The first change is effected by simple hydrolysis, whereby the acetyl group is replaced by hydrogen. The result is polyvinyl alcohol[5], in which the alternate carbon atoms of the chain become linked to hydroxyls.[6] The final change is effected by reacting pairs of hydroxyls with single molecules of an aldehyde, whereby the aldehydic groups become attached, through oxygen atoms, to pairs of these same alternate carbon atoms of the original chain.[7] This is the typical acetal structure,[8] from which these resins take their name. The chart shows, as alternatives, structures resulting from the use of formaldehyde and of butyraldehyde, the difference lying only in the size of the aldehyde nucleus which is thus built into the resin.[9]

So much for the material and the tools used in tailoring these resin molecules. Next in order is a brief ac-

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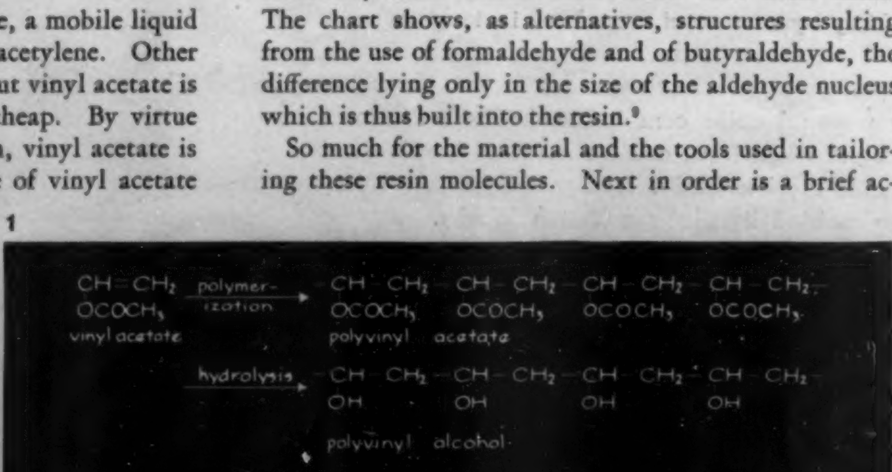
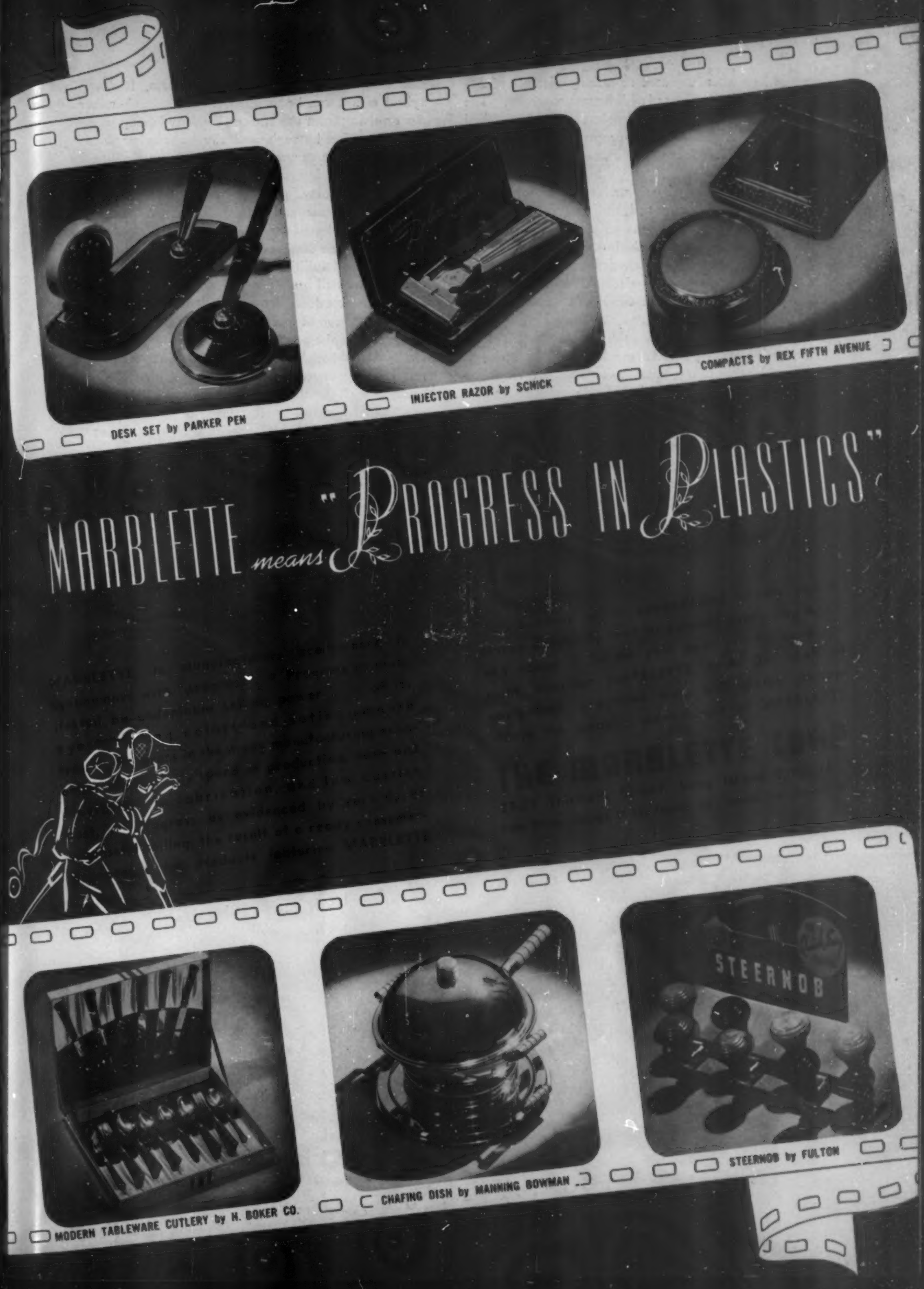



DESK SET by PARKER PEN
INJECTOR RAZOR by SCHICK
COMPACTS by REX FIFTH AVENUE
MARBLETTE means "PROGRESS IN PLASTICS"
STEERNOB
MODERN TABLEWARE CUTLERY by H. BOKER CO.
CHAFING DISH by MANNING BOWMAN
STEERNOB by FULTON

count of how these are used to tailor molecules of different sizes and patterns and of different properties. The size and structure of the macromolecules of the finished resin, and correspondingly its properties, are governed by suitable choice of four variables, namely:

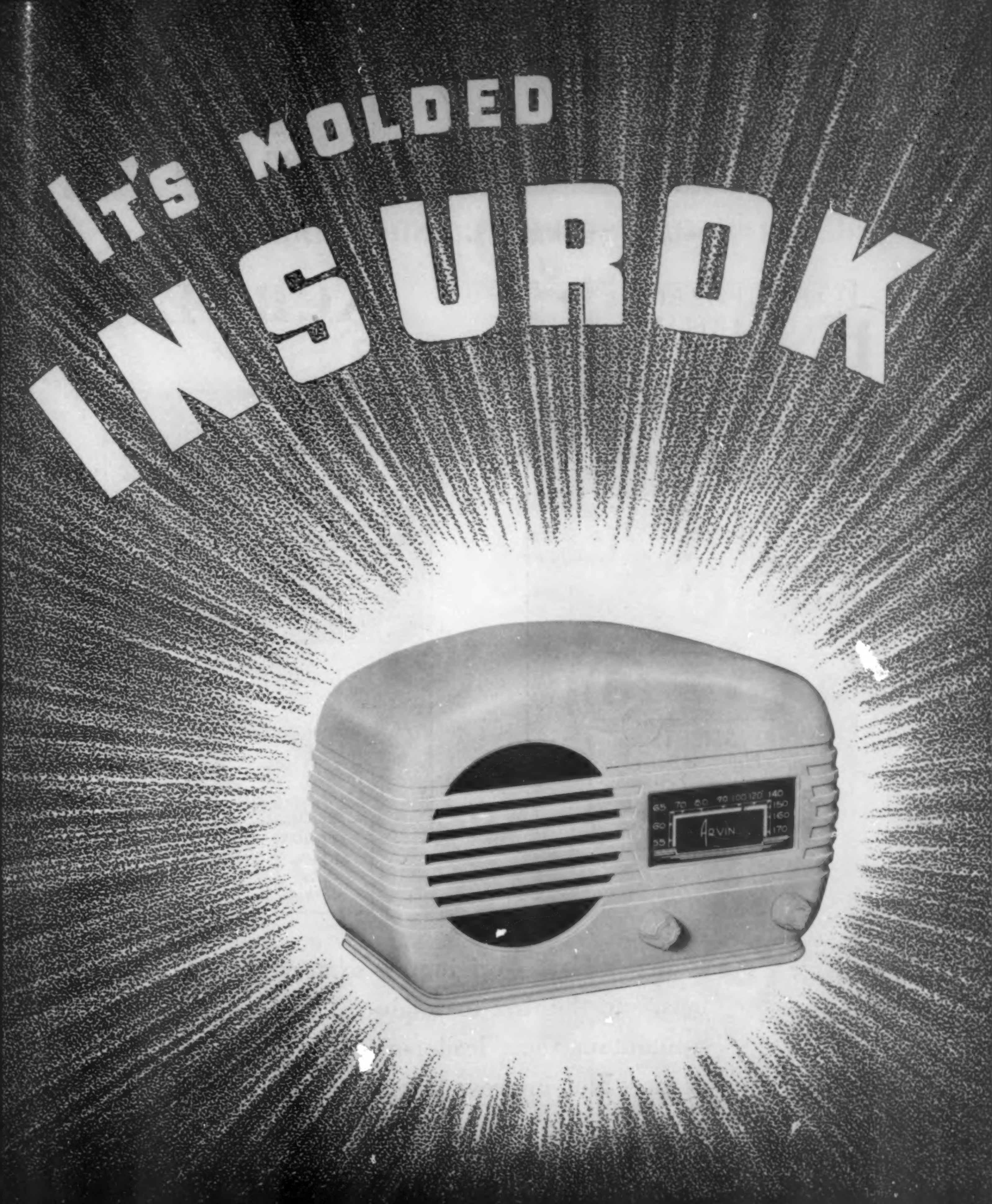
(1) the conditions of polymerization to which the vinyl acetate is subjected,
(2) the extent to which the polyvinyl acetate is hydrolyzed to polyvinyl alcohol,
(3) the character of the aldehyde used,
(4) the extent to which available hydroxyl groups of polyvinyl alcohol are condensed with aldehyde.

The size of the macromolecule, i.e., the length of the chain —CH—CH_2—CH—CH_2— in the final resin, is governed by that of the macromolecule of polyvinyl acetate from which it is derived, and this is subject to control through the conditions under which the initial vinyl acetate is polymerized.[10] In view of the known relationship between molecular weight and viscosity for linear polymers,[11] and the direct bearing of viscosity on the technique of use, it is customary to express the molecular size indirectly in terms of the viscosity of the resin. Practically speaking, the polyvinyl acetal resins of the higher viscosities are characterized by being somewhat the less tacky in a given composition with plasticizer, and of course require the use of the greater proportions of solvent for a mixture of given consistency.

Theoretically any aldehyde, and in actual commercial practice any of several inexpensive aldehydes, may be built into a polyvinyl acetal resin. And since each confers somewhat different properties, the choice of aldehyde gives another means of varying the properties of the product. Formaldehyde, acetaldehyde and the butyraldehydes are being used, and mixtures, leading to hybrid resins, can be used. Differences in characteristics resulting from the choice of aldehyde may to some extent be offset by variations along the other lines indicated, but the generalizations may be made that formaldehyde, the lowest aliphatic aldehyde, yields polyvinyl acetal resins of maximum rigidity, maximum softening temperature and minimum compatibility with solvents and plasticizers, that the butyraldehydes yield resins which are softer, of lower softening temperature and of wider solubility characteristics, and that the use of aldehydes still higher in the series would still further emphasize these differences.

If the reaction of hydrolysis is not carried to completion, some of the acetyl groups are left undisturbed and are carried through as such into the final resin. Correspondingly fewer hydroxyl groups are available for reaction with the aldehyde. The step of condensing the available hydroxyls with aldehyde can likewise be stopped at various distances short of completion, so that some of the hydroxyl groups also are carried through undisturbed into the final resin. Because of the practical difficulty, or the needlessness, of carrying to completion the reactions of hydrolysis and of condensation, and also because of the desirability, for certain purposes, of the presence of residues of polyvinyl acetate and polyvinyl alcohol in the macromolecule of the final resin, the polyvinyl acetal resins of commerce almost invariably contain such residues. These resins can thus be regarded, for purposes of description and control, as made up of A percent of polyvinyl acetate, B percent of polyvinyl alcohol and C percent of polyvinyl acetal, these three percentages totalling one hundred. This does not mean that these resins are mere mechanical mixtures of three ingredients, for this they obviously are not. But the

Control room for the solvent recovery stills is shown below, at left, and apparatus called "Cyclones" which are used to recover the powdered vinyl acetal resin from the air used in drying at the Arlington plant appear at the right. (All photos courtesy du Pont)



Arvin Table Radio manufactured by
Noblitt-Sparks Industries, Inc.

The RICHARDSON COMPANY

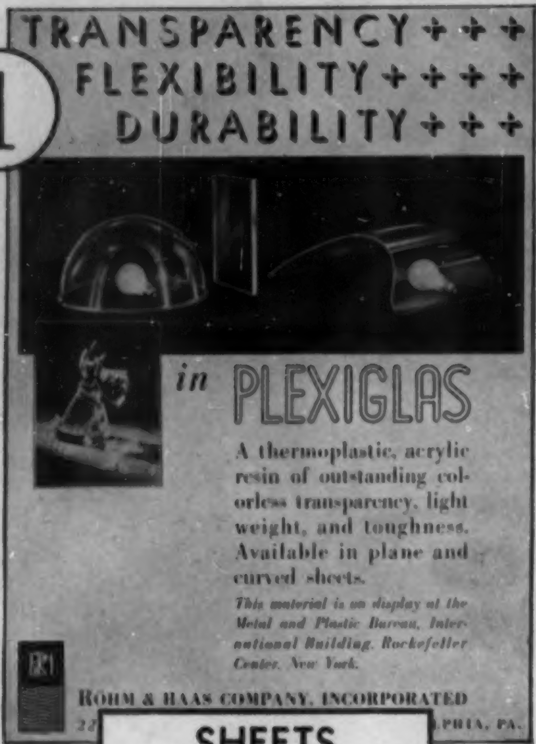
Melrose Park, (Chicago) Ill. — Founded 1858 — Lockland, (Cincinnati) Ohio
New Brunswick, N. J. — Indianapolis, Ind.
Detroit Office: 4-252 G. M. Building, Phone Madison 9386
New York Office: 75 West Street, Phone Whitehall 4-4487

PLEXIGLAS*

SHEETS—PLANE AND FORMED

ACRYLIC

1



SHEETS
Plane and Formed
Marketed since
MARCH, 1936

2

COMPRESSION MOLDING POWDER
Marketed since
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Röhm & Haas—originators of acrylic resin products, and the first to produce them commercially—maintain their leadership in the development of new and improved forms of these materials.

RÖHM & HAAS
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CRYSTALITE*

INJECTION AND COMPRESSION MOLDING POWDERS

RESINS

—and now soon available

3

INJECTION MOLDING POWDER

Marketed since
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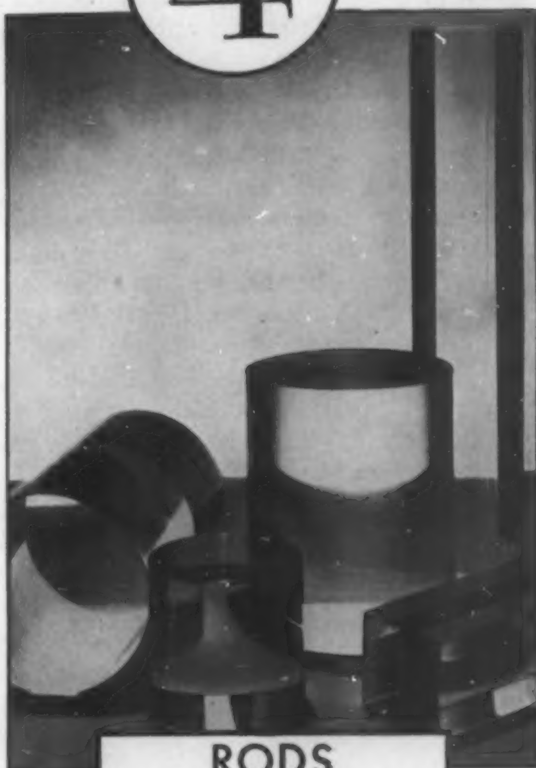
4



RODS

Watch for announcement in an early issue of "MODERN PLASTICS"

COMPANY, INC.

PHILADELPHIA, PENNA.

*Reg. U. S. Pat. Off.

One of the huge reaction kettles used in one of the steps in the manufacture of vinyl acetal resins (above left) and storage tanks for the refined vinyl acetate used in its manufacture. (Photos courtesy du Pont)

question of what is the actual structure of the macromolecule may be the subject of some controversy and is not within the province of the present article.

Variations in the percentages of acetate, alcohol and acetal in the analysis of the final resin can be deliberately effected by varying the conditions of manufacture, and exert distinct and largely predictable effects upon the properties of the resin. This is illustrated in part by the diagram of Fig. 2. Any single point within the triangle represents a resin, of which the analysis, in terms of the three components, is automatically expressed by the respective distances of the point from the three sides of the triangle. One such point is shown, in the center of the circle. Suppose now that the resin corresponding to this point has been made, and is found, by actual test, not to be just what is wanted for a certain purpose; it is, for example, not adequately compatible with ester plasticizers. What change in process should be made in order to correct this deficiency?

Past experience, transferred to this diagram in the form of directional arrows, indicates that this compatibility can be improved by working down toward the lower right hand corner, i.e., by increasing the percentage of polyvinyl acetal and correspondingly decreasing that of polyvinyl alcohol. To accomplish this requires simply a suitable change in the conditions of the reaction of condensation which will cause this reaction to proceed more nearly to completion. At the same time it is evident from the other arrows in this area that the new resin will be better than the other in water-resistance also, and in solubility.[12] It may also, of course, be less desirable in respect to some other property, not noted in the present diagram. It would be too much to expect that all desirable properties should reach their peaks in a single resin. Hence the necessity of selecting, for a given use, the one which combines a maximum of desirable properties, and a minimum of undesirable, and of then conducting the steps of manufacture so as to produce a resin of the desired viscosity and analysis.

The value of the polyvinyl acetal resins as material for the interlayer for safety glass has been recognized for several years,[13] and they are now available in commercial quantity for this purpose. At present the ones most in favor for this use are those made with butyraldehyde, but research is still in progress to determine what combination of viscosity (*Please turn to page 123*)

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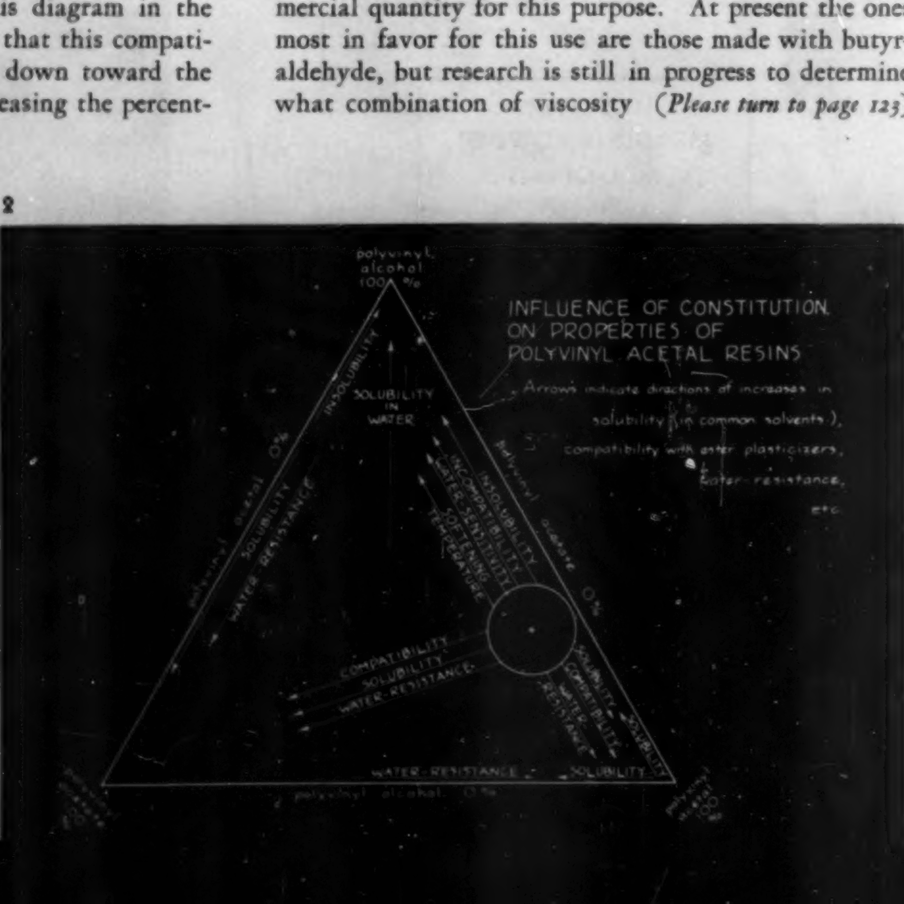


PRINTING, STAMPING, ENGRAVING, INLAYS

WE ALWAYS LIKE TO START WITH THE GENESIS of our subject, so if we go back to the time when molded plastics first began to replace molded shellac insulation, we shall find that even then there was a need to mark such molded products with some sort of identifying marks, trade names, numbers, or directions for use. But plastics were tough babies in comparison with the materials that came before them. They were unimpressed with hot stamping. Their surfaces were so much harder, and of course were unaffected by heat, that any lettering or numbering required to appear on the finished piece had to be cut into the mold and molded in.

Cutting letters and numbers into a hardened steel mold is a slow and expensive procedure but even today this method is followed by many who wish their trade-mark or identifying numbers or initials to become a permanent and integral part of the molded piece. Letters cut into the mold are not so costly, but raised lettering always results. When a manufacturer wants his lettering to be recessed so that a contrasting color can be wiped into the recessions, then cutting raised letters into the mold becomes a matter of considerable cost. When production figures are expressed in terms of the National Debt, the cost of mold engraving is not of such momentous importance because it can be distributed over a year's production and the cost per piece is almost nil.

Individual pieces can, of course, be numbered or stamped with a sharp steel die, whammed (gently) with a hammer, but since this action displaces the material and there is no place for it to go, a mechanical effect is sure to result which adds none to the beauty of the piece.

As soon as plastics began to creep out of the insulation applications where they were cradled, it became evident that some means of printing or marking, both for identification and decoration had to be created. It was also evident that whatever methods were evolved must be practical to use on a few thousand parts as well as in quantity production, and that the cost couldn't be such that it would prevent the finished piece from competing in price with other materials.

Well, all this is water under the bridge. There are so many satisfactory methods of marking plastic products now that any manufacturer may take his choice and can achieve almost any result he has in mind.

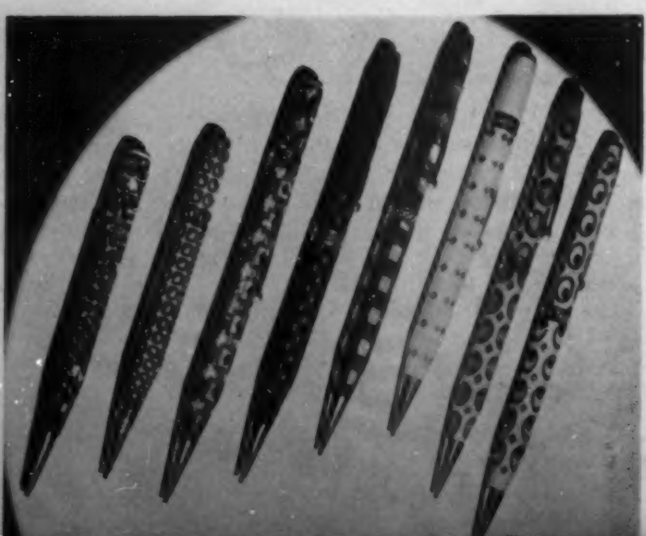
Printing

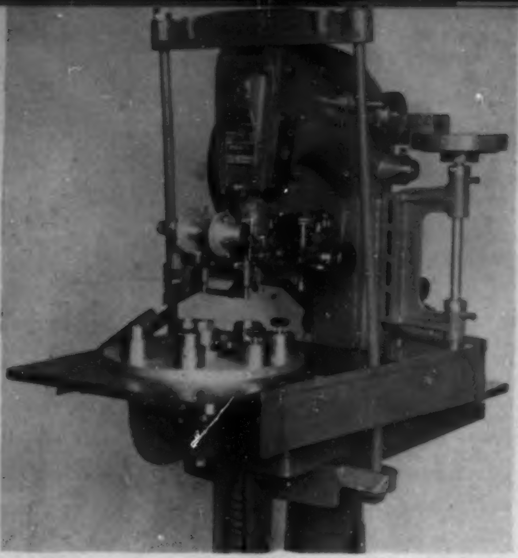
Printing, perhaps, is the most widely used method of marking plastic products. You see it on fountain pens, radio dials, instrument panels, packages, slide rules, advertising novelties, and laminates, and if it is well done it makes a very satisfactory method indeed. Printing, however, is not as simple as it may sound. To begin with, plastic surfaces are hard and non-porous. Ordinary printing inks seem to resent any application to plastic surfaces and shrink into a corner like a scared rabbit. They just won't spread and stay put.

Inks specially developed for compatibility with the type of plastic to be printed have made it possible nevertheless to economically print on almost any plastic surface with assurance that the printing will survive. A number of individual methods have been worked out, most of them patented, and these are available to any manufacturer who wants to letter or decorate his product for easy identification.

By one process it is possible to print on plastics in four colors with one operation. Half-tones and line cuts may be accurately reproduced. The articles to be printed are automatically fed from a hopper and when the printing

Printing on flat, round, even tapered surfaces, is accomplished by Quick Point Pencil Co. by a patented process. Pencils below show no overlap of pattern nor joining lines





PHOTOS COURTESY PEERLESS ROLL LEAF CO., INC.

Roll leaf stamping is a popular method of marking plastics and white or colored foils are used on various machines. The press above is specially designed for stamping plastic sockets

process is completed, automatic conveyors carry the parts through an electrically controlled oven where, for thirty minutes, they are subjected to carefully regulated temperature which results in the printing becoming homogeneous with the piece. Such printing will resist the action of moderate solvents and also the wear and tear which often defaces paper labels. An important feature of this treatment of plastics is that the oven heat is so controlled that no shrinking, distortion or discoloration of the plastic material takes place.

The method described is used largely for printing on phenolics and ureas. These plastics belong in the thermosetting group which means that they are exceptionally hard, non-resilient, unaffected by heat. But there is another group of plastics upon which a vast amount of printing is being done by an entirely different patented process. This group embraces the thermoplastics which are more resilient, and which can be softened again by heat and reshaped. Most of the work about to be described has been done on cellulose nitrates and cellulose acetates which are available both in sheets and tubes of varying sizes and shapes.

Pens, pencils and pocket knives perhaps, have received the greatest amount of attention, but there is no reason why cosmetic containers, make-up kits, lipstick containers, certain decorative handles, and other applications where the product doesn't come in contact with excessive heat in use, shouldn't take advantage of the special characteristics of these two types of plastic material and the decorative printing process which has been worked out especially for them.

The majority of pens and pencils offered through regular retail channels or as advertising novelties are made of thermoplastics usually supplied to the manufacturer in the form of tubing, extruded in various shapes and sizes of standard length. This tubing is sometimes turned, tapered, or shaped by the manufacturer to meet his own requirements, then fitted with mechanical appurtenances which determine its ultimate use. Mechanical screw feeds are inserted for pencils with continuous leads. Erasers and metal tips, which act as propellers are attached.

Pens are made much the same way but with ink sacs and depressing levers for filling, or with pumps or vacuum devices to accomplish this necessary function. Pen points and feeds of different qualities are inserted by various means, determined usually by the ultimate selling price of the pens.

Printing on extruded tubes, although their surfaces are clean and smooth, is not exactly a printer's picnic. Nor are plastic materials the printer's notion of an ideal substance on which to print. To begin with, the tubes vary in circumference no matter how carefully they are extruded. Shrinkage takes place to a certain degree in every tube after it comes from the extrusion machine. It is easy to see therefore, that some complications might develop when it becomes necessary to print an all-over pattern around the circumference without leaving a seam or any lap-over of design.

It is being done as accompanying illustrations will testify and the process has been so carefully prepared that neither seams nor overlapping of patterns occur. Printing is done in one, two or three colors with register as perfect as though the surface were flat and perfectly stable. More than that! Printing is done on tapered, ribbed, fluted, octagonal, hexagonal and other diversified external shapes without distorting the printed pattern in the least. Trick is to print while the tubing is in its original shape, then by a mechanical operation, change the shape to a taper, fluted, octagonal, or whatever shape is desired without distorting or damaging the printed surface. This can be done only on thermoplastic materials which can be reshaped by reasonable heat after the printing operation has been completed.

Tapers are extremely hard to print, due to their varying diameter as they approach the small end. It would be practically impossible to control the impression, even though the printing plate were curved, because the circumference of the tubing varies materially with the decreasing diameter. To overcome this, a patented print-

ing press has been invented on which tubing of various sizes is fitted to a mandrel, where complete printing impressions can be duplicated without any seam or "streak" showing where the plate joins.

Any slight variance in the size of the tubing with respect to diameter, makes the change in circumference about three times as great. It naturally would be impossible to print on tubing by ordinary printing methods because there is almost constant variation in the diameter sizes due to extrusion and shrinkage. By this process, however, it is possible to successfully print on tubing which varies as much as 0.10 in. and still get a complete impression from the same set of color printing plates with almost perfect register.

This makes it possible to reproduce such patterns as snake skin, grained wood, mother of pearl, plaids in all their brilliant hues, mottles, metallics, or almost any you can think of. And while this process was developed by a manufacturer of advertising pencils, the demand has been so insistent by makers of other products that he has recently made it available to any who care to use it. The printing, of course, to be done in his own plant.

Pocket knives are being printed with pictures, trade names, even photographs, using from one to four colors, and perfect register is being obtained even though the surfaces of the knives vary in thickness as much as 20/1000 to 30/1000 of an inch. Anyone familiar with printing will recognize that to control impressions, particularly multi-color impressions, with such wide variance in the articles passing through the press, is quite an accomplishment. The printing on these knives is unusual only in this respect.

Other forms of printing are available to manufacturers whether they prefer to install the necessary equipment in their own shops or send their products out to be printed by experts who have become accomplished in the arts. Flat printing on acetate sheets has become standard practice for radio dials and similar applications and there are methods which permit equally good printing on opaque or translucent laminates of phenolics or urea.

Stamping

Roll leaf stamping is a popular method of imprinting on plastic surfaces, especially where the printed part is likely to be handled a lot in use, because it is deeper than a surface application. Heat and pressure are required to force the metallic or pigmented leaf into the plastic surface and it becomes so fused into the material that it cannot be scratched or rubbed off. This sort of stamping came into being when radio tube manufacturers required their product to be indelibly identified with a color contrasting to the bases themselves.

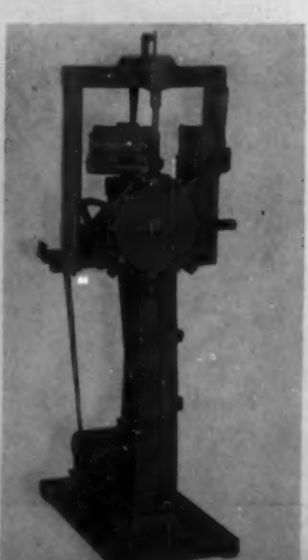
Since then, roll leaf stamping has found wide application in the packaging field where plastic crown closures were difficult to identify or decorate before the method was perfected. Tooth brush handles were a natural for this type of marking because constant every day handling had little eradicating effect on the lettering which went below the surface and the manufacturer's name was clearly visible when the brush was ready to be thrown away. Toiletware manufacturers found that leaf stamping was quite as acceptable on lower priced sets as metal inlays, which cost much more, and lost no time in making use of the process in many ways.

There are many types of machines available for the process of roll leaf stamping. They operate by hand, by foot, or by mechanical power and may be controlled manually or automatically according to the demands of the operation or the plant in which they are employed.

Roll leaf, which is composed of either metallic or pigmented colors mounted on paper to provide a means of carrying continuous color through the machine, is placed on a bar in front of the head of the press. The leaf then winds down beneath a die, and is threaded into a roll feed attachment which is gaged to pull exactly enough leaf into place to take care of each single impression. Thus, new leaf takes the place of old at each impression with little waste. The leaf contains properties which make it possible to transfer with heat, and the die and head of the press is electrically heated and controlled by a switch or thermostat to insure uniform temperature while it is in operation. Presses are equipped with various mechanical handling and compensating devices which take care of any ununiformity in thickness and shape of the pieces being stamped.

Flat stamping may be done with brass or steel type, but for decorative designs, signatures, trade-marks and such, hand-cut steel dies become necessary. Brass is usually strong enough and sufficiently heat resisting for stamping cellulose acetates and other thermoplastics but phenolics and ureas require the strength of hardened steel, either in type or dies. A combination stamping and embossing die may be used on thermoplastics but is not practical for use on (*Please turn to page 73*)

PHOTOS COURTESY MARKEM MACHINE CO.



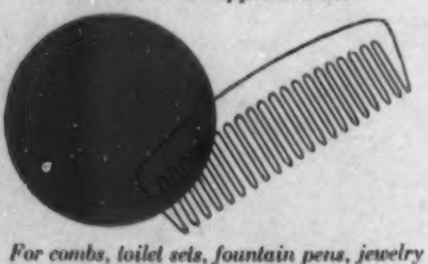
Here is a different style of press for printing radio tubes and cylindrical objects, also samples of the work it does

ANOTHER QUALITY PRODUCT OF

Plastics Headquarters–

Bakelite Cellulose-Acetate Molding Materials

For steering wheels, trim, door handles and other motor car appointments.



For combs, toilet sets, fountain pens, jewelry and other personal accessories.

For electric fan and vacuum cleaner housings or other appliance parts.

BAKELITE CORPORATION now announces a further advance in its facilities for making available varied useful types of synthetic plastics at a single source. Consistent with the fixed policy of the organization, Bakelite Cellulose-Acetate molding materials are now being offered to industry only after exhaustive research and development have established their superior quality.

Gem-Like Lustre, Color, Translucency

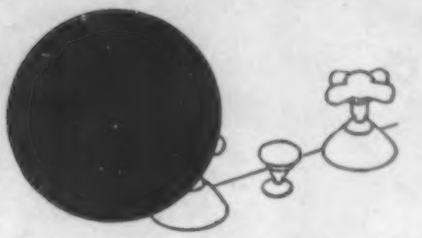
With Bakelite Cellulose-Acetate materials, opportunities for finer product-styling are practically unlimited. These new materials produce molded parts of definitely improved surface lustre. They are furnished in an extremely wide range of colors, in opaque, translucent and crystal-clear transparent effects, as well as mottled or variegated colors.

Exceptional Toughness

An outstanding merit of all Bakelite Cellulose-Acetate molding materials is their horn-like toughness and resiliency. They not only possess high tensile

and impact strengths, but also tend to cushion mechanical shocks and vibration.

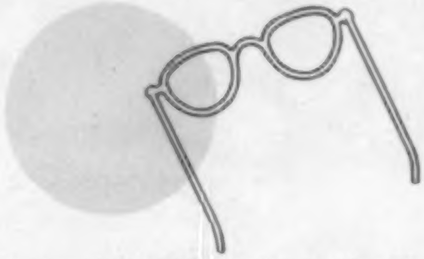
This characteristic, combined with their relative lightness in weight, gives them unquestioned superiority over many other materials for various uses.



For tap and valve handles, and other plumbing or building hardware.

Adaptability in Production

Bakelite Cellulose-Acetate molding materials are custom-made thermo-plastics. Their molding properties and finished characteristics may be varied to suit a diversity of specific uses. Supplied in convenient granular form, they are recommended for either injection or compression molding.



For spectacle and goggle frames, binocular housings and other optical goods.

Samples on Request

For independent testing in your own laboratory, samples of Bakelite Cellulose-Acetate molding materials in granules and finished color checkers will be furnished on request. Please state the application you have in mind and the quantity of material you will require.

For telephone handsets, switch plates, flashlights and other electrical devices.

As these are custom-made materials, initial samples cannot be supplied in special colors. Other characteristics, however, will be representative.

Tables of properties and characteristics showing extreme values available within the entire Bakelite Cellulose-Acetate group, are presented on the following page.

BAKELITE

TRADE MARK REG. U. S. PAT. OFF.

The registered trade-marks shown above distinguish materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products.

BAKELITE CORPORATION

247 PARK AVENUE, NEW YORK, N. Y.

PROPERTIES

Bakelite Cellulose-Acetate Materials

The physical and electrical data given on this page have been determined by A.S.T.M. standard tests employing A.S.T.M. test specimens. The ranges of values indicated cover the many varied materials in the Bakelite Cellulose-Acetate group. They do not indicate variations for any one material in this classification.

FABRICATION (RAW MATERIAL)

Granulation .... 1/8—5/16"
Apparent Density ....0.50—.55 grams per cc.
Plasticity ....Soft—Medium—Hard

Molding Temperature, Injection .... 325—500° F
Compression 300—350° F.
Molding Pressure, Injection ....10,000—25,000 lbs. per sq. in.
Compression ..... 2,000— 5,000 lbs. per sq. in.

PHYSICAL (MOLDED)

Specific Gravity ....1.27—1.50
Impact Strength, energy to break—ft. lbs.....0.4—1.8
Tensile Strength, lbs./sq. in. ....3,000—6,500
Transverse Strength, lbs./sq. in. ....6,000—7,000
Molding Shrinkage, in./in. ....0.00025—0.008

Heat Distortion, °F. 120-195
Softening Point, °F. 180-250
Hardness, Rockwell—R 80-120
Refractive index ....1.47—1.51
Light transmission (crystal) ....80—90%

CHEMICAL RESISTANCE (MOLDED)

Water absorption, 96 hours at room temperature 1.5—3.0%

Acids and alkalies.... dilute—slight effect
concentrated—decomposes

Effect of.... 1. time—slight aging.
2. sunlight—slight.
3. heat—slow burning rate.

Solvents—*Soluble* in ketones and esters, i.e.—acetone, ethyl acetate, cellosolve. Affected slightly by alcohol.

Insoluble—In hydrocarbons, i.e.—benzine, toluene, styrene, carbon tetra chloride, oils.

Note: Elevated temperatures influence the action of both solvents and non-solvents inducing swelling.

ELECTRICAL (MOLDED)

Dielectric strength (step method) ....325—400 volts per mil

Resistivity .... $1x10^6$—10^8 megohm—cms.

	@ 60 cycles	@ 1000 cycles	@ 10^6 cycles
Power factor	.01— .04	.020— .060	.035— .060
Dielectric constant	4.9 —6.2	4.5 —6.0	4.0 —5.0
Loss factor	0.05—0.25	0.17 —0.36	0.14 —0.30

FINISHING (MOLDED) *Restricted by Thermoplastic Character*

Machining ....Satisfactory
Trimming ....Recommended

Buffing and polishing ....Satisfactory
Metal inserts....Specially suitable either molded or driven

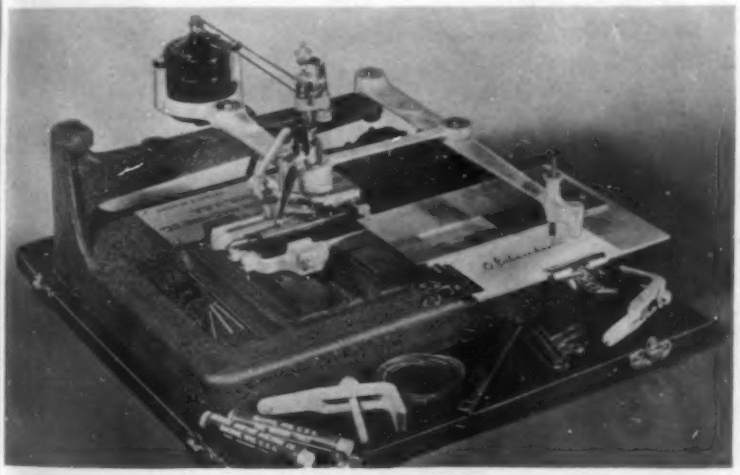
(*Continued from page 68*) thermosetting materials.

Stamping presses have been highly developed for rapid production in special applications. For example: A tooth brush manufacturer whose product had a molded acetate handle and a small hole at the top for hanging, wanted his trade name imprinted across the handle. He began having it done by hand with a production of about 50 brushes a minute, but they had to be dried before they could be handled, and the hole still had to be drilled and polished by hand. A special press was designed where the handles are fed into a hopper, stamped and ejected at the rate of 110 a minute. The machine drills the holes and countersinks at the same operation.

Roll leaf stamping is not always metallic or color. Radio dials, scientific instruments, measuring devices, exposure meters and similar objects where accurate spacing of measured lines is essential to the successful operation of the device, are employing this process to insure permanent visibility of these important demarkations. White is usually used since it contrasts strongly with the dark colors in which these things are usually made.

Engraving

Most of the plastics can be engraved by hand, using conventional tools and methods, but since these materials are usually applied to mass manufacturing, hand engraving is essentially an expensive and ineffectual operation. There is a demand, however, for individual engraving on plastic objects and to meet this demand, machines have been planned and built.



This portable engraver, made by George Gorton Machine Co., engraves on flat or curved surfaces with a rotating cutter guided by hand on the pantograph principle

Department stores, some years ago, sought a practical and inexpensive means by which they could engrave a customer's name on a fountain pen or pencil. Perhaps this was to justify, in a measure, the price they sometimes charged when the lowly fountain pen and extruding pencil were lifted from the 5-and-10 cent level to the five-and-ten dollar bracket. In any event, a light, portable machine was developed which engraves lettering and designs on such articles, also on cigaret lighters and holders where monograms or signatures are frequently desired. It is entirely suitable for use in retail stores for personalizing merchandise and it is equally useful to manufacturers for marking plastic samples in their plants.

The machine uses no heat and does no stamping. The engraving is accomplished by cutting the letters or designs with a rotating cutter driven by a small universal motor mounted at the rear. After the lettering or design is cut (approximately .005 in. deep for plastics) it is filled in with gold, silver, or white paste or lacquer according to the contrast desired.

The machine will engrave flat, curved, or oval surfaces and the result is permanent since it is cut with sufficient depth to prevent the wiped-in color from wearing off. Besides its usefulness for the purpose described, the machine can be used for some methods of inlay which we shall describe later on.

Inlays

Some inlays are embedded in plastics during the molding operation; others are applied cold, and some may be plated on by certain processes without disturbing the original surface at all. Plating of course, is not an inlay in the strict sense of its meaning but since comparable decorative effects may be obtained by plating, we shall include this process in our discussion.

Since each type of inlay is handled by a different method, we shall treat them separately and before we begin it may be well to point out that inlays are also used in laminates as well as in molded parts and thermoplastic sheets, rods, and tubes. Inlays for laminating may be metal or they may be contrasting colors of the materials being laminated. They are cut to the desired shapes from impregnated laminating stock or from thin sheets of metal, then they are laid in place on the sheet to be laminated and fastened there with an adhesive. A protective sheet of laminating paper impregnated with urea is laid over the top and the whole thing is placed in a laminating press. When the sheet is removed from the press, the top protective sheet has become transparent and is therefore invisible, leaving the inlaid pattern firmly embedded in the sheet and permanently a part of it. The inlay is flush with the surface of the sheet and no joining lines can be seen or felt. Since laminating inlays of this sort are accomplished in the manufacture of the sheets in the original plant we shall dismiss them with this brief description, but finished laminated sheets and parts are capable of accepting both the cold inlays and metal plating about to be described.

Generally speaking, inlays are of metal. They are stamped out of thin stock in the desired shapes and are available from a number of sources, either from stock designs or cut to specifications. Some molders have used them successfully in hot molding over a period of years, while others have found it difficult to anchor the inlays in the mold in such a manner that they are not disturbed by the molding operation. When inlays are to be molded in, they must be placed (*Please turn to page 76*)

MOLDERS SERVICE

CHILTON METAL INLAYS

ALERT manufacturers, who have already utilized the advantages of plastics, will welcome the news that the Chilton Process for permanently inlaying metal into plastic materials, is available thru their molder.

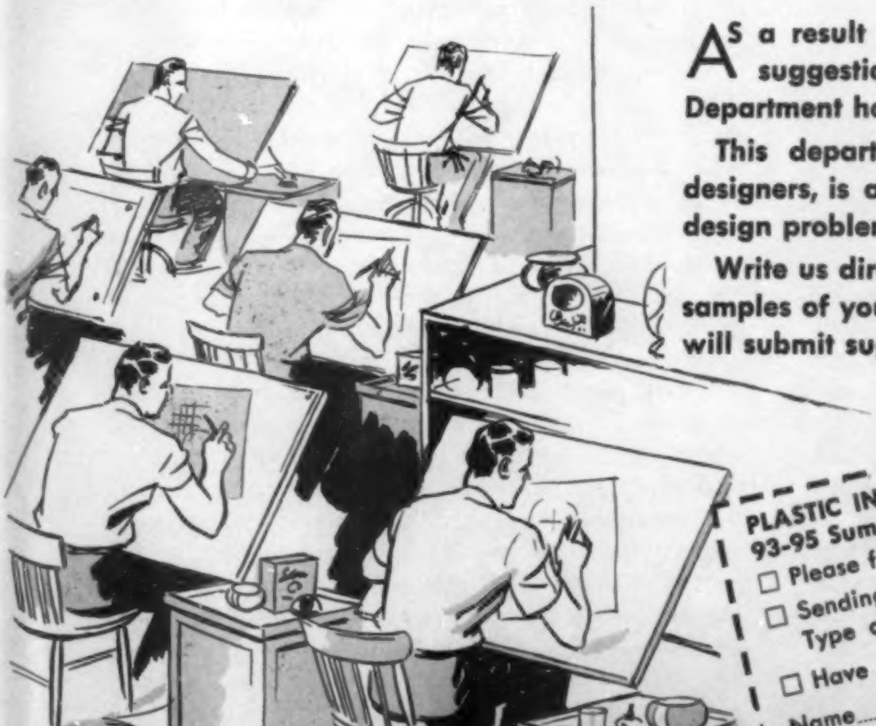
The often-discussed possibility of combining the numerous features of plastics with the beauty and eye-appeal of metal inlays is now a reality.

New beauty... New durability... New sales appeal can be incorporated into your product at a surprisingly reasonable cost.

The progressive molders listed on the opposite page are familiar with the Chilton Metal Inlay Process. Their representatives are qualified to discuss the application of metal inlays to your product.

PLASTIC INLAYS, INC.
93-95 Summit Ave., Summit, New Jersey
Detroit: 810 Stephenson Bldg. Trinity 1-0354

A DESIGN DEPARTMENT TO HELP YOU



AS a result of the numerous requests for constructive suggestions incorporating metal inlays, a Design Department has been organized.

This department, manned by experienced industrial designers, is available to any manufacturer who has a design problem.

Write us direct or thru any of these molders. Send us samples of your product, blue prints or drawings and we will submit suggested improvements.

PLASTIC INLAYS, INC. (Design Dept.)
93-95 Summit Ave., Summit, N. J.
☐ Please forward literature about Chilton Metal Inlays.
☐ Sending you samples, sketch or blueprint
Type of Plastic used ....
☐ Have representative call Mr. ....
Name ....
Address ....

PLASTIC INLAYS, INC
THE CHILTON PROCESS

(*Continued from page 73*) in the bottom of the mold and some satisfactory means must be found to make them remain in that position. Then the molding powder is placed on top and when the hot mold closes with enough pressure to cause the material to plasticize there is considerable rush and disturbance of the hot flowing mass that often unseats the insert and causes it to appear in embarrassing positions on the finished part.

Metal inlays provide plastics with so many opportunities for decorative treatment that a great many companies have been working to perfect methods to meet the consistent and constantly growing demands. One company has worked out a process, which it has patented, whereby inlays are forced into plastic surfaces cold, yet are so shaped that they become anchored automatically and permanently. The method was originally used to decorate plastic pen and pencil sets made by the company, with gold designs in modern motifs. Trouble was that many types of plastics have a tendency to shrink over a period of time and fountain pen material is more susceptible to this change than some of the other plastics.

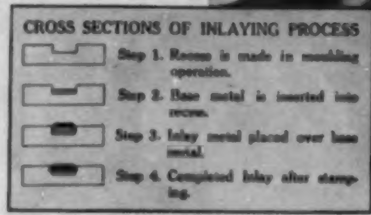
The process is simple enough now that it has been discovered and can be applied to either thermosetting plastics or thermoplastics with equal success. It can be used on laminated materials, too, on either flat or curved surfaces, and here is where that little portable engraving machine which we described a while ago will come in handy. The first requirement of this cold inlay process is a shallow recession following the contour of the inlay to be placed. This may be molded into the piece on production runs or cut in with a pantograph cutter where a variety of designs is to be used.

The inlay is slightly convex (or concave on the back) and is supported by a piece of base metal which is harder than the inlay itself. When pressure is applied to the top, the base metal causes the inlay to spread out on all sides penetrating the plastic walls of the recession, permanently locking it into place. The harder the plastic used, the more difficult it is to wedge the inlay into place and the more permanent it becomes.

Metal plating

Plating, as we have pointed out, isn't exactly comparable to inlays because it doesn't go beneath the surface but those in search of economical methods of decorating plastic products with metallic designs, especially in quantity production, will be interested to learn that such a process is available. Because of their non-porous surfaces, plastics are not easy to plate with metal but a series of patented solutions have been devised which render these surfaces capable of taking electroplate and retaining it.

The treating method is comparatively simple and may be accomplished in any shop equipped with electroplating apparatus. The things to be plated are first cleaned, then placed in a bath of the patented solution where they are agitated by compressed air for about an hour. After this, they are re-rinsed and immersed in a second bath of another patented solution where they are tumbled

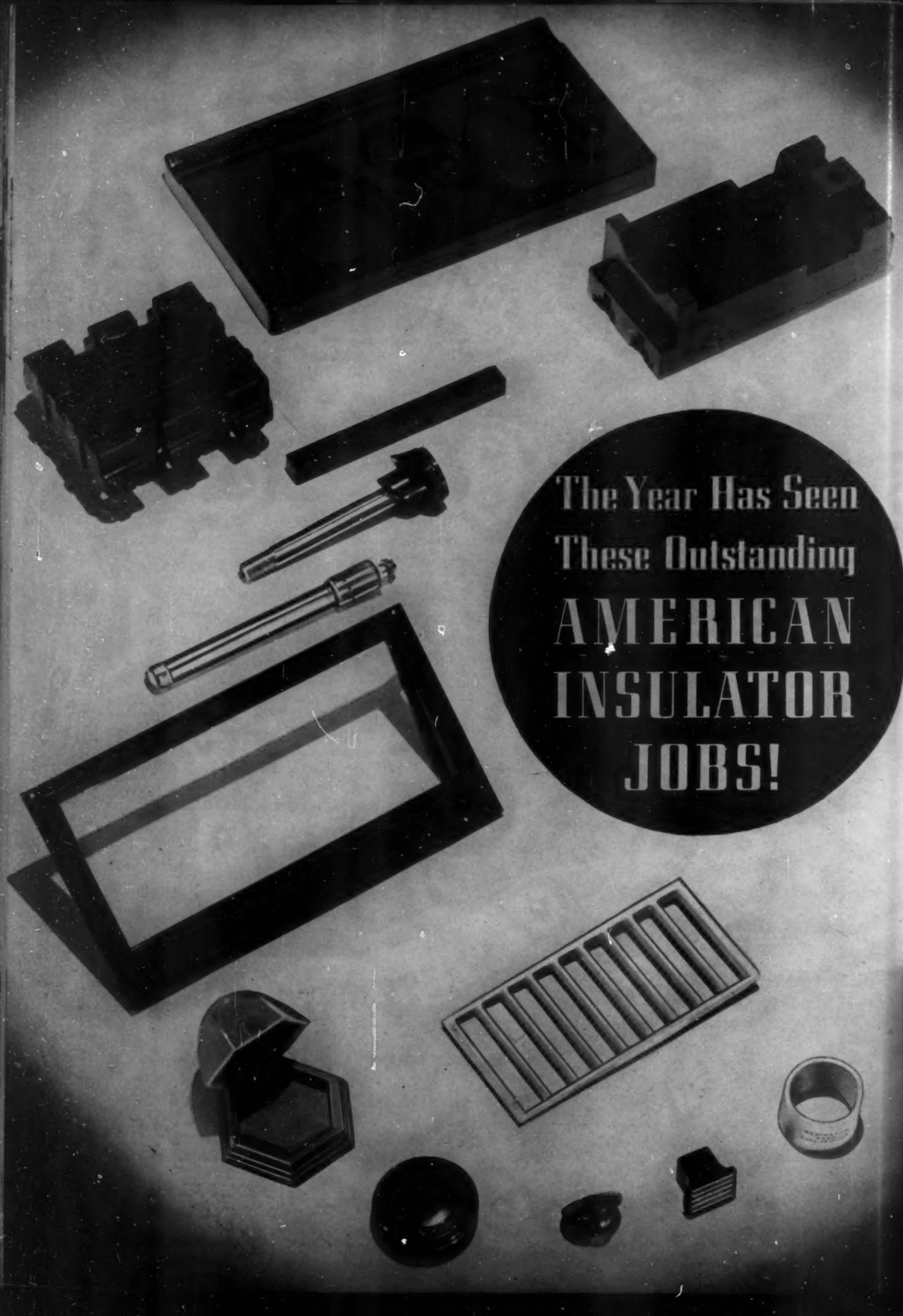


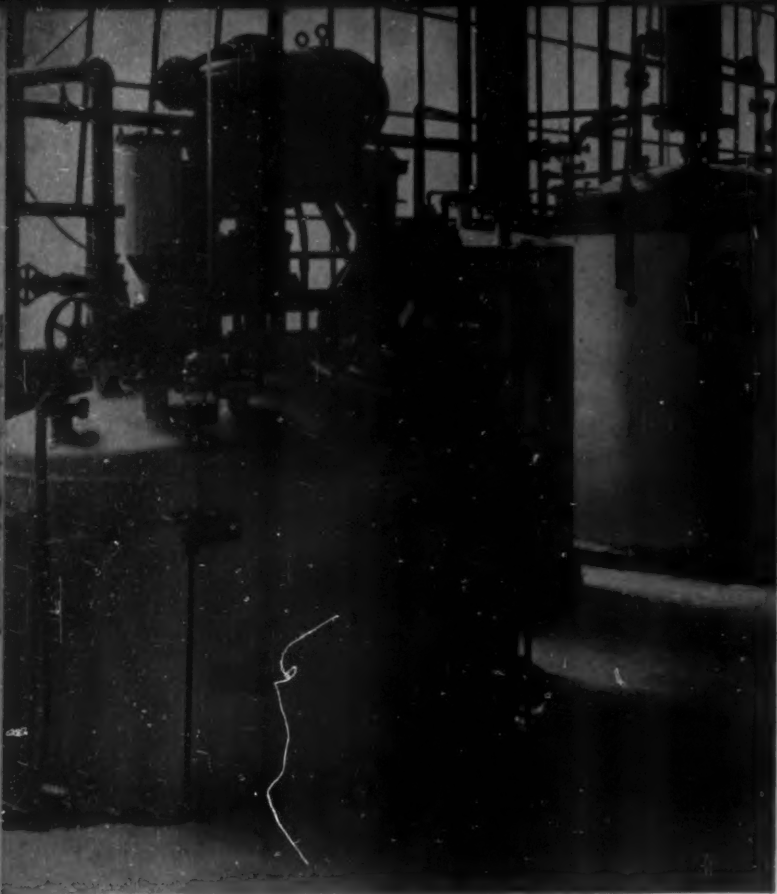
Top photo shows metal inlays in a cellulose acetate strip being flexed to prove they can't pop out. This method, explained by the insert, is called the Chilton Process and is controlled by Plastics Inlays, Inc. Below are sample pieces of plastic, metal-plated by The Metaplast Corporation

about five or ten minutes. Rinsing again prepares them for the plating bath.

Surfaces may be entirely plated, or they may be masked to take the plating wherever it is desired. Gold or silver handles may be plated to contrast pleasingly, yet may be integral with the plastic product of which they are a part. Metal tips may be plated to cigaret holders, bands plated on plastic handles or knobs, ornaments may be plated on plastic jewelry or the entire piece of jewelry can be plated and retain all its advantages of size with light weight. Initials or designs can be plated on packaging containers by masking the surface. There are rumors as this is being written, that a machine is under development which will automatically prepare and plate designs on plastic parts, or plate their entire surfaces with metal of almost any choice. When this reaches the market, which may be before we get into print, an economical method of simulating metallic inlays will be added to the broad choice of methods already described.

If any one has had courage to read this far, he has learned at least, that almost any requirements for marking on plastic surfaces can be met with one or another of the methods described. Some of the results may not meet with your notion of ideal standards but probably before another October rolls around someone will have discovered and patented a technique that will.


The Year Has Seen
These Outstanding
AMERICAN
INSULATOR
JOBS!



Processing kettles for blending, dissolving or emulsifying alkyd resins at Reichhold Chemicals, Inc., plant

Filtering has much to do with the success of alkyd resins in industrial applications

PROGRESS IN ALKYD RESINS

by A. G. HOVEY

DURING THE PAST FIVE YEARS, ALKYD RESINS have been a popular subject, discussed from many angles. Much as has been written about them, there still is as much important matter left unwritten about them as there is apple unrevealed under the superficial skin.

The unmodified resin made from glycerol and phthalic anhydride as described by Smith,[31] Callahan,[4] Kienle,[22] the author[16] and others, has never yet found any widespread commercial application in spite of its outstandingly good color, oil resistance, adhesion, and in spite of the combination of hardness and toughness it possesses when thoroughly cured. The lack of compatibility with oils, nitrocellulose, and with most of the inexpensive solvents is the chief reason for its lack of popularity in the manufacture of finishes, although it has been used in certain specialties, such as commutator varnish, special oil proof insulation, high grade foundry core binders, adhesives, and special high temperature baking primers and finishes. In the molding industry, it has never been successfully used because of its slow curing, its tendency to stick to molds, and because of its tendency to "gas" and form a vessicular structure. In contrast to the procedure on most resins, which is to mold with subsequent curing, the efforts which have been most nearly successful in molding glycerol phthalate resin, have been to reverse the usual procedure, i.e., partially curing first and then molding afterwards, similar to the method described by Wright.[33] A method for studying the imbibition of solvents in resin gels has been suggested by the author[16] and some data on swelling pressures of glycerol phthalate gel given.

The amount of successful commercial application of pure unmodified polyhydric alcohol-polybasic acid resins other than those made from glycerol and phthalic anhydride has been thus far so small as to be almost infinitesimal. In addition to the difficulties which they possess in common with the glycerol-phthalic anhydride resin, many of these unmodified resins have poor flowing and levelling qualities which are so necessary in good finishing materials, often actually forming large craters in the film during baking just as soon as the strong solvent has evaporated. In molding, some of these unmodified non-phthalic alkyd resins have shown at times considerable promise. Safford[28] (*Please turn to next page*)

QUIZ ON PLASTICS

HERE are three questions mighty important to users of modern plastics. If you answer all three right off the bat, you get "A" for today's lesson—and you'll save yourself a lot of homework from now on.

2 *What cellulose acetate plastic, made by the originator of the entire plastic industry, has demonstrated such amazing durability that its sales appeal can be readily applied to products which must withstand tough treatment?*

1 *What 8-letter word is the name of a plastic that has brought new heights of beauty and color appeal to all sorts of modern products in daily use? A few of these products are illustrated above.*

3 *What material has helped molders and manufacturers solve so many unusual problems that it has become their first consideration in all plastic applications?*

THE ANSWER to each question is one word—Lumarith. This "new era plastic", in molding powders, gives easy moldability—low shrinkage in the mold—minimum shrinkage after molding. Lumarith comes also in sheets, rods, tubes and rolls of continuous length which can be carved, cemented to other materials, die-formed, embossed, stretched, swaged, or even hand-shaped. Lumarith is made by the Plastics Division, CELLULOID CORPORATION, 10 E. 40th Street, New York City. Established 1872. Sole Producer of Celluloid and Lumarith (Trademarks Reg. U.S. Pat. Off.)

When you think of plastics, think of headquarters . . . "the Granddaddy of 'em all" . . . and . . .

Get in touch with

CELLULOID

. . also Headquarters for Transparent PACKAGING MATERIALS

LUMARITH

REG. U.S. PAT. OFF.

PROGRESS IN ALKYD RESINS

(*Continued from preceding page*) has described oil proof printers' rollers, gaskets, and flexible insulation produced by special processes from unmodified adipic and succinic esters of polyhydric alcohols. In general, the unmodified resins of this type are still further handicapped by the relatively higher cost of the polybasic acid and by the water resistance which is even less than that of the phthalate resin. There are two special types of unmodified alkyds which possess different properties than those of this general group; one type is the terpene maleic anhydride esters described by Littmann,[24] and the other type consists of the drying type unmodified maleic acid-polyhydric alcohol linear polymers described by Vincent[32] and by Bradley[2] and co-workers. Sorbitol alkyds have been described by Goepp and Brown.[11]

The usefulness of the alkyd resins lagged far behind that of the phenolic resins until it was learned what possibilities lay behind the modified alkyd resins. The non-drying type alkyds were prepared and described 1912–1915 by Arsem,[1] Howell,[19] and Friedburg,[8] but with the exception of corn oil, it was not until 1921 that Kienle[21] recorded the formation of a drying type alkyd which subsequently was the basis of his application filed in 1927 and not granted until 1933. It has been contended[10] that Kienle's substitution of drying fatty acids for the non-drying fatty acids used by Arsem[1] was not an invention because the introducing of drying characteristics into the resin was to be expected, yet, however, it has been pointed out by Bradley[2] that not all polyhydric alcohol esters of drying fatty acids possess air-drying properties, even though the glycerol esters do.

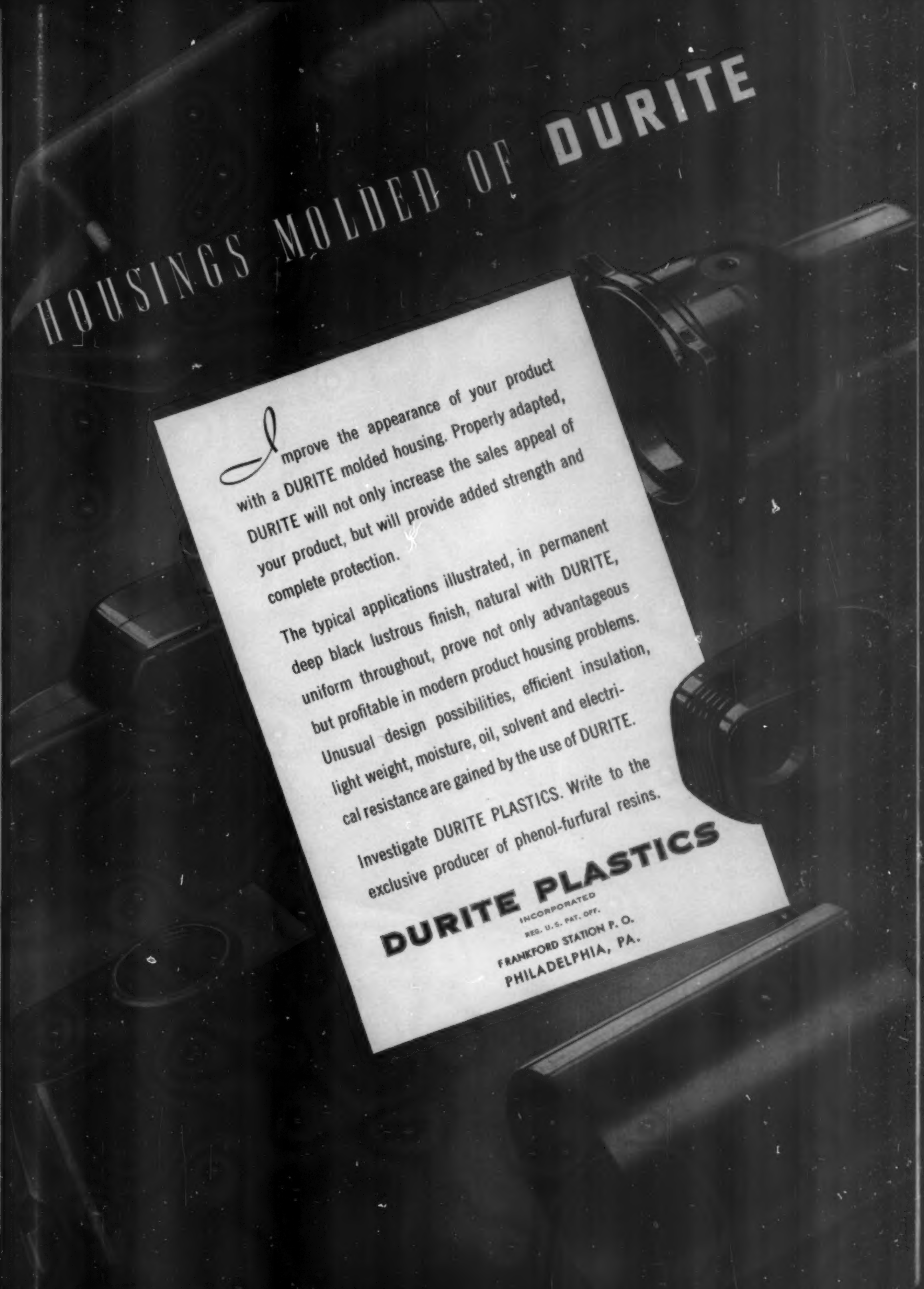
Aside from the fact that the cost of phthalic anhydride came down from the price of a chemical curiosity in the pre-war days to a price at which it could be used commercially, two factors enormously stimulated the production of alkyd resins in the period of 1923–1933. One was the widespread use of nitrocellulose lacquers as the high speed metal finish brought about by the needs of the automotive industry, and this offered a big outlet for suitable lacquer resins. Resins are absolutely necessary in exterior lacquers to improve adhesion, cut down permeability, and for imparting humidity resistance and for durability. The other factor was the growing realization that alkyd resins, when properly used either with or without nitrocellulose, had outstanding durability, i.e., resistance to weathering. Many stories were circulated in those early days, about 1925, that alkyd resins acted as a stabilizer to nitrocellulose and were sometimes called "nitrocellulose preservers." Regarding these claims that alkyd resins are stabilizers for nitrocellulose, there never has been demonstrated any actual proof that alkyd resins increase the chemical stability of nitrocellulose (as such stabilizers as diphenylamine increase the stability of smokeless powders). The truth of the matter is, no doubt, that the superior durability of the alkyd resin enables the formulation of more durable lacquers, by surrounding each nitrocellulose particle with durable resin particles. The increased durability of the lacquer makes it look as if the nitrocellulose had been stabilized.

The alkyd resins which have been used in exterior lacquers have been mostly the non-drying type on account of their freedom from the objection of "lifting" on recoating. Certain drying type alkyds have given very satisfactory service and superior water resistance in lacquers when the lifting tendency has been recognized and steps taken to correct this fault. The tendency in the use of drying alkyds, due to the fact that the alkyd has been cheaper than nitrocellulose, was to cut down the expensive ingredient more and more until the finish became all synthetic resin. About 1932, one of the largest automotive manufacturers came out with an "all-synthetic" enamel, possessing long luster life and durability, and making several substantial savings over lacquer in both the non-volatile content and in the cheaper solvents which could be used, and also by a reduction in the number of spray applications necessary. From then, the alkyd resin, whether in lacquer or in all-synthetic enamel, has shown a record performance of durability for outdoor exposure on metal that is the standard by which all prospective formulas are judged.

Since ester gum, described by Eugen Schall[28,29] between 1883 and 1893, had long been used in nitrocellulose lacquers to replace the more expensive natural resins, it was only natural that the rosin-modified alkyds (or looking at it the other way as alkyd-modified ester gum) should be found useful in the furniture lacquers since the early twenties. These rosin-modified alkyds (often called "hard alkyds") in contrast to the soft oil-modified alkyds which are used for the exterior lacquers, have much higher melting ranges than ester gum; and due to this fact, have found wide usefulness in sanding sealers and sanding lacquers for wood finishing, because they may be sanded and polished soon after application.

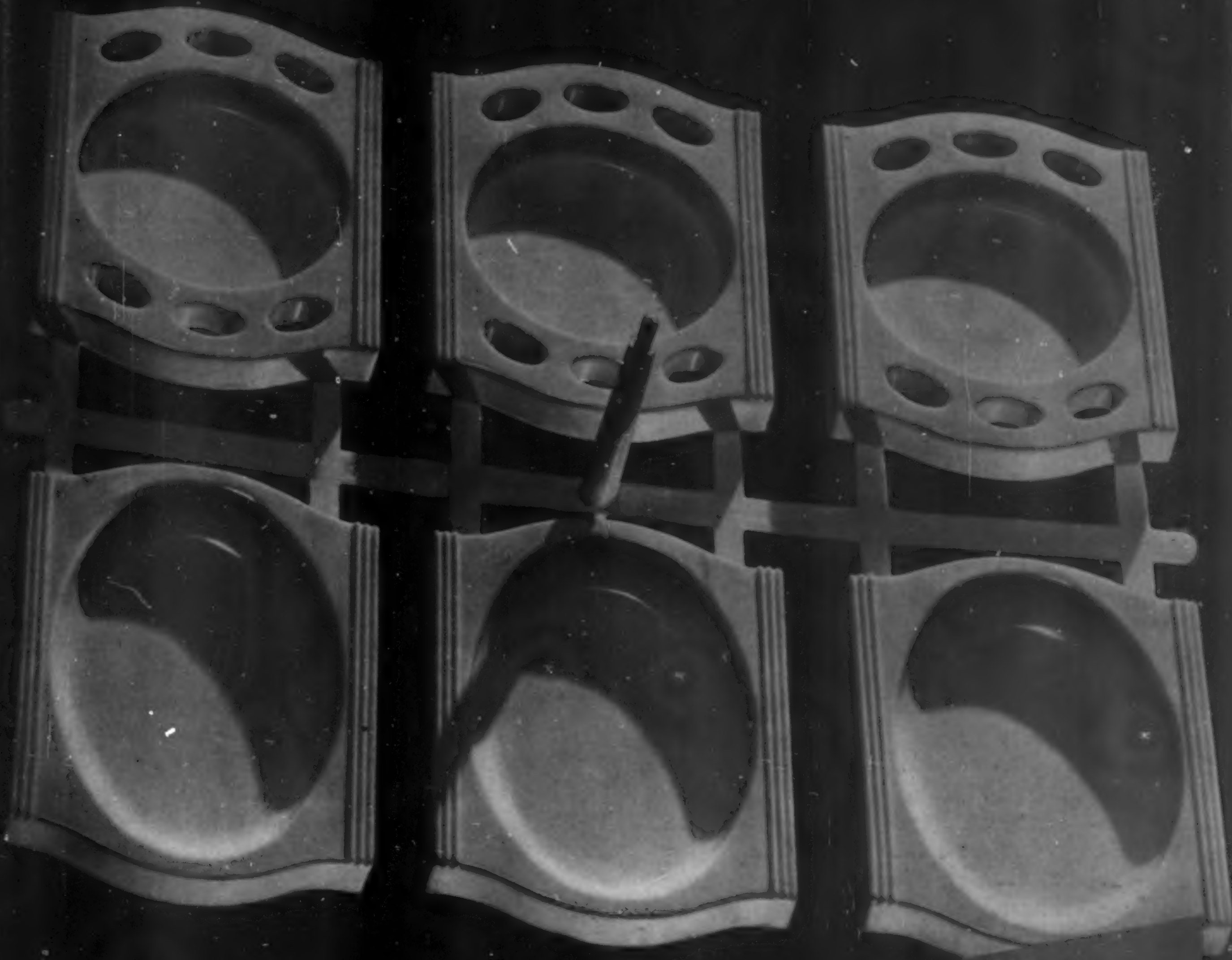
It was also only natural that these same hard rosin-modified alkyds which, on account of their higher melting ranges, make harder and quicker sanding lacquers than ester gum, should for the same reason replace ester gum in oleoresinous varnishes when greater hardness is also desired. On account of their superior color retention, they are used instead of modified phenolic resins for tin-decorating varnishes and for white enamels. In general, the rosin-modified alkyds do not find their way into exterior finishes to any extent, the resins for exterior purposes being usually proclaimed as "free of rosin, rosin ester, or rosin derivative" or as "pure alkyds."

The name "pure alkyds" would seem to designate unmodified polyhydric alcohol-polybasic acid resins. However, in paint and varnish terminology, the name "pure alkyd" has come to mean both long and short-oil alkyds, containing no modification by rosin or other natural resins, or by phenol-aldehyde condensation products or other synthetic resins. The versatility of these pure alkyd resins, as pointed out by Ferguson,[7] is very great. In general, the chief reason for their widespread use is their resistance to sunlight on exterior exposure. Their durability record has stood as the highest standard for the last twelve years, unsurpassed (*Please turn to page 86*)


HOUSINGS MOLDED OF DURITE
Improve the appearance of your product with a DURITE molded housing. Properly adapted, DURITE will not only increase the sales appeal of your product, but will provide added strength and complete protection.
The typical applications illustrated, in permanent deep black lustrous finish, natural with DURITE, uniform throughout, prove not only advantageous but profitable in modern product housing problems. Unusual design possibilities, efficient insulation, light weight, moisture, oil, solvent and electrical resistance are gained by the use of DURITE.
Investigate DURITE PLASTICS. Write to the exclusive producer of phenol-furfural resins.
DURITE PLASTICS
INCORPORATED
REG. U.S. PAT. OFF.
DURITE
FRANKFORD STATION P. O.
PHILADELPHIA, PA.

THE BRODIMATIC COUNTER, *a petroleum meter, enclosed in a Tenite housing. Compression molded by the Hahn Plastic & Die Cast Corp. for the Ralph N. Brodie Co., Inc.*

It's Only the Beginning—



CELLOWARE, soap trays and tumbler holders, injection molded by The Paul A. Norris Co. for the B. & T. Floor Co.

(*Continued from page 82*) by any other class of coatings formulated within the realm of organic chemistry. Other good attributes are their excellent color and gloss retention, adhesion and comparatively good resistance to heat. The unusual longevity and the retention of original appearance of these finishes precludes the necessity of early refinishing. These are the reasons for the popularity of alkyd resin finishes for all sorts of articles which are exposed to the weather. This includes not only metal goods, such as automobile and truck finishing, farm machinery, gasoline pumps, bicycles, metal signs, bridges and structural steel, but also building materials such as, house paint, trim and trellis paint, brick paint, composition shingle enamel, not forgetting such important miscellaneous items as sunproof awnings, traffic paint, the covering up of unsightly asphalt, and similar applications.

"Pure alkyds" when used as baking finishes, gain greater hardness and adhesion than when air-dried, and at the same time, retain the good features of the air-dried finishes of the same type, i.e., durability and comparatively long-time retention of original appearance. All sorts of metal goods are finished with baking finishes of this type, but the two most important examples are finishes for automobiles on account of durability, and those for refrigerators on account of color retention and humidity resistance. Pure alkyds tend to increase the durability of films of other materials when admixed with them, such as cellulose esters, chlorinated rubber, drying oils, varnishes, paints, enamels, etc. Baking increases the resistance of alkyd formulated refrigerator enamels to soap and water, humidity and grease. These enamels which are made of short oil "pure alkyd" resins may often be used for white enamels for washing machines and laundry equipment.

Where white or light color is not essential, the resistance of washing machine finishes to these enamel enemies may be stepped up greatly by the use of "phenolic-alkyd" resins which are oil-modified alkyd resins further modified by highly reactive phenol-aldehyde condensation products, such as those described by Hoenel.[15] This increases the water and alkali resistance of the alkyd with some sacrifice in color retention, and is a useful compromise between the durability of the pure alkyd and the water resistance of pure phenolic varnish. In very humid, hot climates, they have better durability than the pure alkyds. The phenolic modified alkyds are much more resistant to water and dilute alkali than the pure alkyds. The use of such alkyds in automotive refinishing enamels cuts down the amount of time necessary to make the enamel "showerproof." These "phenolic-alkyds" are especially valuable in formulating inert, humidity-resistant metal primers and economical, hard, tough toy enamels. The original color, color retention and gloss retention of this class of alkyds have been somewhat sacrificed through the phenol-modification in comparison with the pure alkyds, but in most cases, any objections can be overcome by intermixing with the phenol-free type of alkyd resins.

The production and use of flush colors has grown tremendously in the past two years on account of their merits due to convenience and economy. Many of these are furnished with alkyd resins as the vehicle base, partly on account of the widespread use of these resins, but mostly to keep the desirable characteristics of the enamel from being diluted by the admixture of oils or other substances which are also used as "flushing vehicles." For example, flushed colors to be used in a white exterior enamel of high durability should be furnished with a base vehicle of the same type, i.e., a long-oil pure alkyd. Correspondingly, the flush color for a water-resistant air-drying colored enamel should be a phenolic-alkyd which insures the maintenance of these properties. With reference to lacquers, the flush color should be made with a resin which is compatible with nitrocellulose. The use of long-oil pure alkyd resins as universal dispersing media for pigments has kept increasing, because of (1) compatibility with nitrocellulose, oils, paints and varnishes and most materials commonly used in coatings; (2) good "wetting" and dispersing properties; (3) when added to other materials, they do not detract from durability and usually add to it; and (4) color is light.

The use of alkyd resins in interior architectural finishes is rapidly increasing. These enamels, when made from the pure alkyds, have excellent retention of original appearance, light color, good flowing and levelling characteristics and almost no tendency to "bloom". Their rapid drying is a good asset together with the fact that they are easy to clean. The phenolic alkyds have a very important place in interior colored enamels as they also have good gloss, very fast drying, good hardness, and their superior resistance to water and cleansers gives them an added advantage over the pure alkyds, where washability at frequent intervals is necessary. According to Krumbhaar,[23] phthalic resins are also, as a rule, more reliable than varnishes from the point of producing non-blooming finishes.

The popularity of the recent emulsion paints, made on the basis of alkyd resins, is well deserved. Before going into the merits of this type of product, it is interesting to look backwards and see by what a long, drawn-out, gradual, orderly process the development of alkyd resin emulsions took place. It appears that the fundamental discovery underlying the production of water paints of this type was made back in 1860 when Emerson[6] disclosed the process of making a water paint from a drying ester (flaxseed oil) emulsified in an aqueous alkaline colloidal suspending medium. Before the turn of the century, "cold water paints" were described in many old recipe books, such as the one by Jamieson[20] in 1897 who gives two formulas, both of which call for the dispersion of a drying glyceride ester (linseed oil) in alkaline water with a proteinous material in the colloidal state (glue) used as the suspending agent. One former paint manufacturer alone tells of having made over 10,000 gallons of one item of oil-water paint before the start of the World War, to say nothing of his competitors. Scott[30] gives several formulas for making casein solutions for water paint and also one for making rosin size from a suspension of hard resin in alkaline water. (*Please turn to next page*)

(Continued from preceding page) Inasmuch as the long-oil alkyd resins have come to take the place of the linseed oil paint on account of better proven durability, better hardness, luster life, chalk resistance, tint and gloss retention, etc., it was not only natural and obvious to think of emulsifying alkyd resins on account of superior durability instead of linseed oil to make water paints of superior durability, but it also meant continuing right along the same lines of chemical operation because these resins, like linseed oil (especially if the oil is bodied) are also glyceride esters of drying oil fatty acids.

The alkyd resin film made from properly formulated emulsion paints (hydrophyllic colloidal dispersions), subsequent to the evaporation of the water, is converted by oxygen, as might be expected, to a very durable water-insoluble coating in the same manner as it would be if the film had been made from the non-aqueous solution of the corresponding alkyd resin in hydrocarbon solvent. Since the paint already contains water, the paint may be applied before the surface to be painted is dry. This is, of course, a tremendous advantage, for now a durable coating may be applied over wet woodwork, brick, stone, concrete, etc., if the surface is clean, whereas formerly, it was necessary to wait for dry weather for paint application in order to prevent the formation of blisters from the vaporization of entrapped moisture. It has already been pointed out by Gardner[9] and the author[17] that alkyd resins have excellent exterior possibilities, especially for whites and light colors to cover over unsightly asphalt where heretofore, "bleeding" of the asphalt into the paint has prevented the application of light-colored, durable coatings. Hadert[12] has discussed pigmentation of emulsion paints for many applications. It is quite likely that the emulsification of alkyd resins will assist in making them eventually more attractive in the preparation of molded compounds and for special large scale operations where the expense and fire hazard of solvent evaporation has kept them less attractive. Also, the alkyd resins in emulsion form have possibilities of miscibility, when desired, with certain other materials with which they are ordinarily not compatible, as for example, with the phenol-formaldehyde molding resin. Thus it will be seen that developments tracing back to a date before the War between the States for their start, lead on, one after another, till a point is reached where many new avenues are opened up.

The use of other resins to harden alkyd resin films has increased greatly in the last three years, particularly in the case of baking enamels. The addition of small amounts of concentrated oil-soluble phenolic resins of the reactive type greatly harden alkyd baking enamels, but with some sacrifice in the color. Urea resins, which have the property of hardening alkyd resin films without detracting from the color, are becoming increasingly important for such applications as refrigerator, bicycle and toy enamels and coatings for such metal furniture as beds, office equipment, kitchen cabinets, and washing machines. Urea resins of this type, used for hardening alkyds, have been discussed by Cheetham,[5] Pearce[25], Hill and Walker,[13] and by Hodgins[14] and the author.[18] These urea resins are preferably used with the non-drying type of alkyd resin and baked at temperatures of 300 deg. F. and upwards to take full advantage of hardening without discoloration. At such temperatures, they yield light-colored, glossy films of bone-like hardness and are surprisingly inert, the inertness greatly increasing as the baking temperature increases.

With all the progress in alkyd resins in other fields, it is really surprising that more has not been done with the oil modified alkyds as molding plastics, because their good exterior durability and color retention should make them attractive for outside work. No doubt some pioneer will show the way to use them successfully in this field before much longer, possibly with the miscible types of urea-formaldehyde resins to harden them up rapidly.

Alkyd resins have done much to brighten up the world with beautiful, long-life surface coatings. Just to imagine how ugly things would now seem without alkyd resins after growing more and more used to them, let us consider all the beautifully colored automobiles the way they used to be fifteen years ago—dull and black, and if left out as long in the weather as most of us do now, they soon became rusty too. The white electric refrigerators were not in existence fifteen years ago, but if they had been, the finishes of that day would have had them yellowing, or with rapid rusting tendencies. Streamlined trains, buses, trucks, and street cars, thanks to alkyds, are things of beauty today compared to what their counterparts were fifteen years ago. Progress in finishing has kept abreast of technical progress in other fields, thanks to progress in alkyd resins. When long-life finishes are desired, formulate with alkyds!

Literature Cited

1. Arsem, U.S.P. 1,098,777 (1914).
2. Bradley, Ind. Eng. Chem., 29, 579 (1937).
3. Bradley, Kropa, and Johnston, Ind. Eng. Chem. 29, 1270–1276 (1937).
4. Callahan, U.S.P. 1,108,329 & 1,108,330 (1914) and others.
5. Cheetham, Paint, Oil, and Chemical Review, 99, pp. 42, 44, June 10, 1937.
6. Emerson, U.S.P. 27,280, Feb. 28 (1860).
7. Ferguson, Modern Plastics, *15*, No. 2, p. 14–15 (1937).
8. Friedburg, U.S.P. 1,119,592 (1914); C. A. 9, 179 (1915).
9. Gardner, Circular 533, Scientific Section of National Paint, Varnish and Lacquer Association, p. 176, May (1937).
10. General Electric Co. vs. Paramet Chemical Co., U. S. District Court, Eastern District of New York, Equity #7192.
11. Goepp and Brown, Paper presented before the Paint and Varnish Section of the A. C. S. at Rochester, N. Y., Sept. 6, 1937.
12. Hadert, Farben-Chemiker, *8*, 408–12, 421–2, December (1937).
13. Hill and Walker, U. S. P. 1,877,130, Sept. 13 (1932).
14. Hodgins and Hovey, Paint, Oil and Chemical Review, *100*, No. 12, pp. 30, 31, 35, June 9 (1938). Also paper presented before the Paint and Varnish Section of the A.C.S. at Dallas, Texas, April 1938.
15. Hoenel, U.S.P. 1,870,453–5, incl.; U.S.P. 1,968,080; U.S.P. 1,988,353–6, incl.; also paper entitled "Phenolic Varnish Resins," read at meeting of the Oil and Colour Chemists Assn. in London, Feb. 17, 1938.
16. Hovey, "Formation of a Typical Synthetic Resin," Thesis for M.S. Degree, Union College (1927); to be reprinted in Paint, Oil and Chemical Review, July 7, 1938.
17. Hovey, Paint, Oil and Chemical Review, 99, June 10, 1937; also Modern Plastics, *15*, No. 4, p. 56, Dec. 1937.
18. Hovey and Hodgins, U.S.P. 2,109,291, Feb. 22, 1938.
19. Howell, U.S.P. 1,098,728 (1914).
20. Jamieson, "Manufacturer's Practical Up-to-Date Recipe Book" published by Ward, Lock & Co., Ltd., 15 E. 12th St., New York (1897).
21. Kienle, U.S.P. 1,893,873 (1933).
22. Kienle and Hovey, "Reaction of Glycerol and Phthalic Anhydride," J.A.C.S., *51*, 509 (1929).
23. Krumbhaar, "Chemistry of Synthetic Resins," p. 109, published by Reinhold Publishing Co., New York (1937).
24. Littmann, Ind. Eng. Chem. *28*, 1150–1155 (1936).
25. Pearce, Official Digest of Federation of Paint and Varnish Production Clubs, No. 167, June (1937), p. 216–220.
26. Safford, British Patent, 403,905 (1934); C. A. *28*, 3852 (1934).
27. Sanderson, Paint, Oil and Chemical Review, 99, No. 22, 9–13 (1937).
28. Schaal, U.S.P. 335,485 (1886).
29. Schaal, U.S.P. 368,494 (1887); U.S.P. 501,446 (1893).
30. Scott, "Formulas and Processes for Manufacturing Paints, Oils and Varnishes," published by Trade Review Co., 610 Federal St., Chicago (1928).
31. Smith, J.C.S.I., *20*, 1075 (1901).
32. Vincent, Ind. Eng. Chem., 29, 1257–1269 (1937).
33. Wright, Chem. & Met. Eng. *39*, 438 (1932); also British Pat. 394,450 (1933) and C. A., *28*, 352 (1934).

Plaster walls in a private home (left) are coated with Aquaplex *alkyd* resin emulsion paint to resist moisture and provide greater flexibility and adhesion. The water-white clarity of Acryloid *acrylic* resin solutions (right) is valuable in finishes. (Photos courtesy Resinous Products & Chemical Co., Inc.)

SYNTHETIC RESIN COATINGS

by DR. W. T. PEARCE

SYNTHETIC RESINS ARE USED IN THE COATING industry in three ways. One way is to apply a solution of the resin, e. g., alcohol solution of shellac. Another is by blending solutions of the resins with other solutions, as in nitrocellulose lacquers. A third way is by processing the resin with drying oils, dispersing metallic driers and reducing the viscosity with solvents, as in the manufacture of varnishes. In the first way, the properties of the film are those of the resin. In the second, the properties are determined by the characteristics of each material. In the third, the properties may approximate the arithmetic mean of the resin and the oil or they may be quite different, depending upon the effect of heat upon the resin and the oil, and of the processing upon the dispersion of the resin in the oil.

The qualities desired by this industry vary widely, depending upon the type of finishes in which they will be used. They are in general, light color, non-yellowing, and either fast drying or quick baking. The coating material should also be easily removed from containers, readily soluble in the solvents generally used or dispersible with minimum difficulty in drying oils. Other desirable properties are resistance to water and alkali, neutrality to basic pigments, and easy wetting of pigments. Cost is usually a large factor. The important types used in the coatings industry are as follows:

Ester gum

Ester Gum is a triglyceryl ester of abietic acid. Compared with rosin, this resin is harder, less reactive with pigments and more water resistant. It is widely used with tung oil in producing water-resistant and other types of finishes, and is frequently included in lacquers to give hardness, gloss, and improved adhesion.

Coumarone-indene

Coumarone-indene is made by polymerizing coumarone and indene, unsaturated aromatic compounds found in coal tar naphthas. These are neutral resins which are resistant to alcohols, alkalies, and acids.

Phenol-formaldehyde

This class of resins has been widely used in coatings for a number of years. They are difficult to classify because the properties possessed depend upon the phenol body used, other materials employed, the catalyst and the method of manufacture. The use of this type of resins in varnishes was developed by Berend, who as early as 1910 discovered that resins derived from phenol and cresols and formaldehyde, which are insoluble in drying oils, turpentine and mineral spirits, became soluble when fused with rosin, fatty acids, etc. This discovery led to the development of certain phenolic varnish resins in 1912. At that time, varnishes in Europe were made almost entirely with fossil gums and linseed oil, so that phenolic varnish resins were first developed as substitutes for fossil resins. These resins met with some success and by 1923 considerably improved resins were available. Investigation in this country led to the acquisition in 1936 of the patents and processes relating to them and the further development of these resins was undertaken here.

The next development of phenol-formaldehyde resins for varnish use was the (*Please turn to next page*)

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SYNTHETIC RESIN COATINGS

(*Continued from page 90*) troduction of the unmodified resins of this class, commonly referred to as the 100 percent type. Simple phenol and cresols with formaldehyde give condensates which are insoluble in drying oil. If the reaction is stopped before the infusible and insoluble stage is reached, a resin soluble in alcohol may be secured. This product, however, is lacking in adhesion and flexibility and is not suited for coating work. In making a resin of this type, it is necessary to introduce into the reaction resins or oils which are in themselves soluble in drying oils. In this way, modified resins varying widely in hardness, solubility and other properties are secured. Examples of the preparation of resins of this type are found in U. S. patent 1,623,901, (April 5, 1927) issued to Amann and Fonrobert.

If alkylated phenols such as butyl, amyl, or octyl phenol, or arylated phenols such as paraphenyl phenol, are used, oil soluble resins may be secured without the introduction of other resins or of oils. These are used alone or with ester gum to produce a let-down type of resin which in some respects is similar to the modified resins referred to. It is difficult to keep metallic driers dispersed in them and finishes containing resins of this type often lose a large part of their drying properties upon aging. When diluted with rosin or ester gum, some of the properties of these resins are retained, notably good color, color retention, water and alkali resistance. Lack of through hard drying is one of the defects of resins of this type. They are used in making finishes which are highly resistant to strong alkali and water.

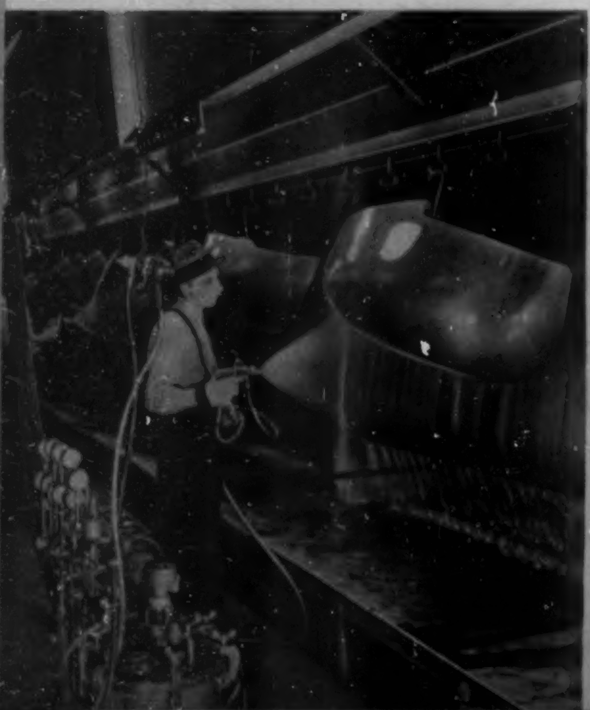
The modified resins are used more widely because of their greater versatility, better through-drying and adhesion. Resins of this type are designed for special purposes and vary widely in melting point, solubility, and hardness. One may be designed for rubbing varnishes, another for floor finishes, and a third for spar varnishes. Such resins give much better through-drying and the harder ones are especially useful in drying linseed oil. They are used in practically all types of fast drying varnishes—floor, spar, rubbing, etc.—in baking finishes, enamels, and paints.

Alkyd resins

The term "alkyd" refers to polymers formed by the condensation of the reaction products of dibasic acids and polyhydric alcohols. Examples of the acids used are phthalic, succinic, maleic and sebacic, and of the alcohols used are glycol, glycerin and pentaerythritol. A large number of resins of this type are made with phthalic anhydride and glycerin. If only these materials are used, a resin will be secured which forms hard, brittle, films possessing poor adhesion and poor water resistance. However, if the fatty acids from castor, linseed, soybean, and similar oils, are included in the reactions, suitable resins for coatings are secured. Properties such as water resistance, adhesion, flexibility, and solubility depend upon the percentage of phthalic anhydride and the oils used. General properties of these resins are excellent initial color and color retention, good gloss and gloss retention, and good durability. When baked, good through-drying, adhesion and water resistance are secured. In air drying finishes, the adhesion, and through-drying secured is dependent on the type of resin.

These resins may be classified in several ways. One way is according to the type of oils used, viz., non-drying and drying. These are sometimes referred to as convertible and nonconvertible. Another method is according to the percentage of phthalic glyceride contained, such as high, medium, and low alkyd content. The high alkyd resins are soluble in aromatic hydrocarbons, but possess limited solubility in petroleum hydrocarbons. They are used in baking finishes usually at moderately high temperature and for blending purposes. The medium alkyd resins are used for low baking and quick drying, and those lower in phthalic glyceride are employed for airdrying finishes such as architectural enamels and mill whites.

The alkyd resins made with non-drying oil find use as plasticizers in nitrocellulose lacquer and in the newer urea-formaldehyde baking finishes. The drying oil resins find application according to their alkyd content: high alkyd resins are used for high baking resins and for blending; medium alkyd for low baking and fast drying finishes; and low alkyd for (*Please turn to page 96*)



Resin base baking finish being applied on metal by spraying (left). Duraplex alkyd resins are reacted in these kettles (right) at Resinous Products & Chemical Company's plant

(*Continued from page 92*) architectural and other air drying enamels.

A different type of alkyd resins is made by using maleic anhydride and terpenes. A special group is made by reacting maleic anhydride with rosin and then esterifying with glycerin. These are hard resins, pale in color, soluble in aromatic hydrocarbons and drying oils. They are specially useful in nitrocellulose lacquers because of their hardness, low solvent retention, and non-yellowing characteristics. When used with drying oils, they produce pale finishes which discolor very much less than those made with phenol-formaldehyde resins. Such resins are used in thin decorating finishes and in many cases where a pale, very slightly yellowing clear finish is needed for a clear coat over white enamel. In general, they are slower drying and less gas resistant than finishes made with modified phenol-formaldehyde resins.

Urea-formaldehyde resins

These were first described by John (U. S. P. 1,355,834, 1920). In their early stages of condensation, they are water-soluble and become water resistant only when cured under heat. Such resins are used in the manufacture of molding compounds, laminated paper and fabric, and in the treatment of textiles. They are unsuited for use in varnishes, lacquers, and similar coatings. A method for producing resins soluble in non-aqueous media and suitable for use in coatings was discovered in 1927. (U. S. P. 1,633,337, Lauter, 1927). It was learned that urea and formaldehyde would react in non-aqueous media to produce resins soluble in alcohols, esters, etc. These resins develop their desirable characteristics only by curing under heat and not by oxidation. Important properties of the cured film are hardness, marproofness, water-white color, non-yellowing, and excellent resistance to solvents. However, the film is quite brittle and it is necessary to use suitable plasticizers to secure adequate flexibility and adhesion. These plasticizers are alkyd resins of the drying and non-drying types, so designed that they reduce to only a small degree the desirable properties of the urea-formaldehyde resins. Formulations with urea-formaldehyde resins are particularly suitable for pale baking enamels with high resistance to abrasion, solvents, and yellowing.

Vinyl resins

When vinyl acetate, which is produced by the absorption of acetylene in glacial acetic acid, is heated with a catalyst, it is converted into a water-white solid. (U. S. Patent 1,672,157, June 5, 1928.) Resins now in use are polymers of vinyl acetate, vinyl chloride or copolymers of these compounds. The resins are colorless, odorless, tasteless, non-toxic, and thermoplastic. They are soluble in nearly all of the common solvents with the exception of gasoline and the higher alcohols. The resins are most widely used in the field of adhesives, but solutions are used for special types of coatings, such as metal linings. Such coatings give good resistance to mineral acids and alkalies, and poor resistance to acetic and similar acids.

Acrylic resins

Acrylic resins are esters of acrylic and alpha-methacrylic acids. Those in use are chiefly polymers of the methyl and ethyl esters and their copolymers. Wide variation in properties may be secured by changing the chemical composition and the process of manufacture. They are water-white and non-yellowing. In general, the methacrylates give the hardest film. In the case of the esters just mentioned, methyl methacrylate gives the hardest and ethyl acrylate the softest film. These resins give films of high luster. They are flexible and give good resistance to water, acids, and alcohol, mineral oils, gasolines, greases, and many chemical fumes. Suggested uses are can linings especially for wines, beer, vinegar, gasoline, and dilute acids, baking finishes where permanent high gloss and non-yellowing are desired, and fume resistant enamels.

Other resins

Other interesting types of resins are: the chlorinated diphenyls which are thermoplastic and non-drying, and find use as plasticizers for lacquers; the polystyrene resins, which are similar in properties to the acrylic resins and likewise expensive; and the petroleum hydrocarbon resins, which are made by polymerizing olefins obtained by cracking petroleum distillates. These latter resins are hard, neutral and soluble in drying oils.

Resins for the future

It would seem that resins suitable for all types of finishes are now available. This, in general, is the case. However, requirements for industrial uses depend largely on the method of manufacture and the conditions of application and use, which are subject to change. Quite often a demand for a finish which can be applied in accordance with a given schedule and possess certain new characteristics, leads to the use of a hitherto neglected resin. There is still no generally satisfactory coating which will prevent rusting and deterioration of metal surfaces of all kinds. This has led to the introduction of new alloys to take care of these types of failures. Tank coatings which will resist petroleum oils and distillates, and which can be applied to the finished tank and not be too expensive, are current demands.

In the trade sales line, there are many opportunities for the introduction of new resin finishes. It is doubtful if any liquids are available for house paints which are as suitable as linseed oil. A finish, comparable in cost, which could be readily applied to oil-painted surfaces and give less trouble from peeling, blistering, dirt collection, and checking or cracking, would be readily adopted. In interior coatings, people generally object to the odor of petroleum hydrocarbons, and the time required to dry hard. Finishes having no objectionable odors and which could be applied and give a hard, dry finish which would have the mar-resistance and durability of an oil varnish, and the speed of drying of shellac, would likewise prove attractive.

UREA MOLDING COMPOUNDS

by WHITING N. SHEPARD

UREA-FORMALDEHYDE MOLDING COMPOUNDS, which have been in commercial production about ten years, were developed principally to provide lighter colors than were available with the earlier produced phenol-formaldehyde materials. But the pure whites, beautiful pastels and brilliant hues possible because of the water white resins used in their manufacture, are not the only reason for existence of the urea-type materials. Certain unique characteristics of this plastic have accounted for its rocketing ascent to prominence in America's fastest growing industry. In addition to the fact that any shade from pure white through the pastels, to deepest black can be manufactured and made completely light fast, the ability of the plastic to retain its original color is of paramount importance in many fields of its application. Further, most colors are made completely "non-bleeding" in alcohol, acetone or any common solvent.

The surface of urea moldings is smooth and lustrous, with the "feel" common to most plastics, and moldings are completely tasteless and odorless, as witness their successful use in the tableware and kitchen field.

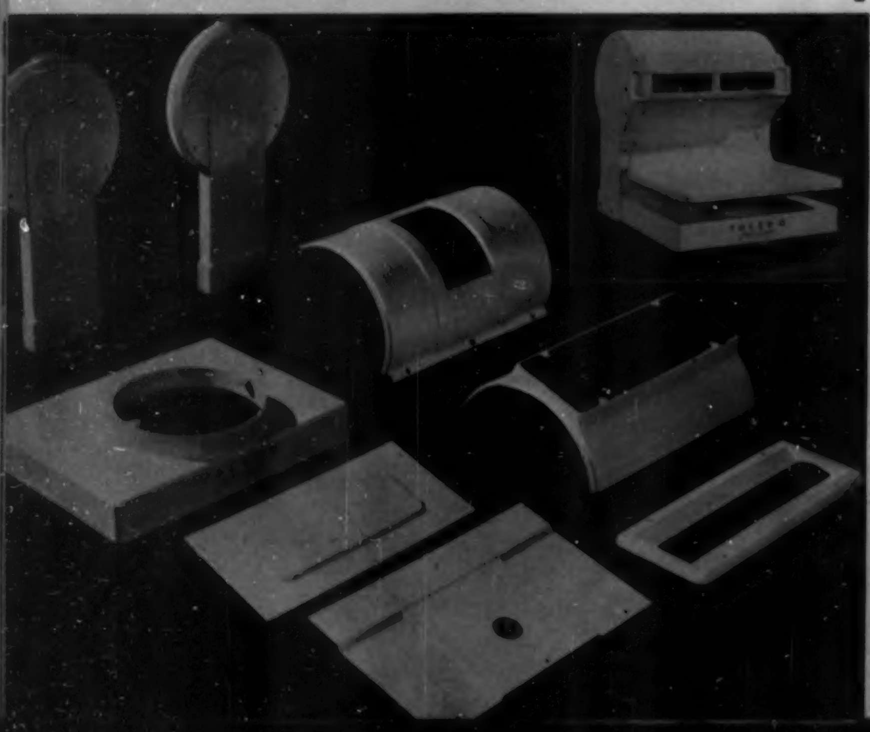
One unique characteristic of pieces molded from urea compound is their hard surface which offers surprising resistance to outdoor exposure. While no organic material yet discovered has the resistance of inorganic materials to the elements, moldings of this material will stand up for long periods of time. In considering outdoor applications, however, it is well to consult the material manufacturer and to arrange that the moldings be cured under optimum conditions.

Urea moldings can be submerged in any common solvent such as alcohol or acetone indefinitely without harmful effect of any kind; they are likewise completely resistant to greases and oils, molded containers having been used extensively in the packaging of creams and salves having oil or grease bases. The effect of weak alkalies and acids on these moldings is nil. Strong acids and alkalies exert a *(Please turn to next page)*

1

Urea molding compounds provide industry with thermosetting materials of light colors and almost unlimited pastel shades. Radio manufacturers use them to boost sales, and the Detrola "Pee Wee" (1) is one of the more recent arrivals. The Toledo Scale (2) indicates a trend toward larger molded housings through assembly of molded parts. (Photos courtesy Plaskon.) Cigaret lighters (3) become gay and practical in a urea molded case. (Photo courtesy Beetle)

2



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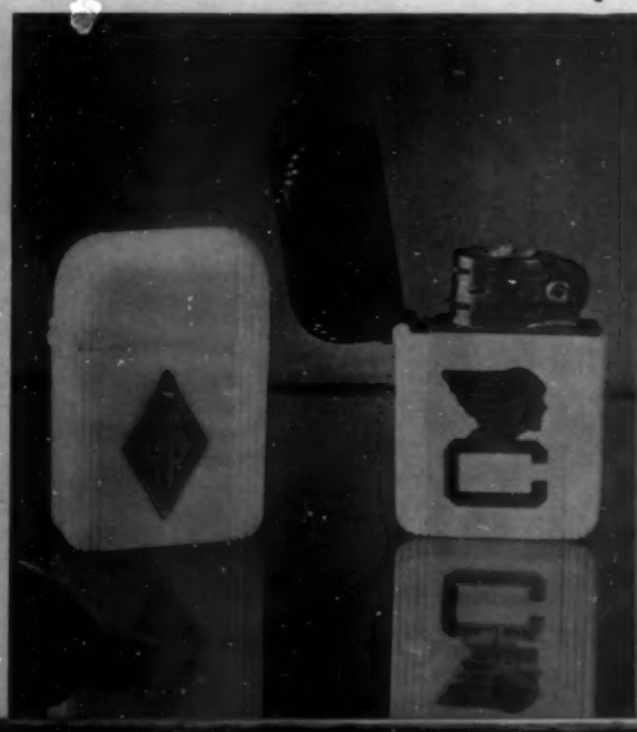


(*Continued from preceding page*) markedly deleterious effect.

Of interest to any manufacturer contemplating the use of plastics in connection with his products is the strength of the moldings. Those fabricated from urea plastics are shatterproof and resilient, possessing a marked degree of flexibility, where thin cross sections are used. The flexural strength ranges from 10,000 to 16,000 pounds per square inch, while the tensile strength may vary from 8,000 to 13,000 pounds per square inch. The range in values is dependent on the degree of cure of the finished molding but the highest values are not generally required for most applications.

Thus it should be mentioned, that special grades of urea-formaldehyde compounds, such as are produced in the phenolics by varying the filler for high strength, moisture resistance, etc., are not made, due partly to manufacturing difficulties and partly to lack of demand.

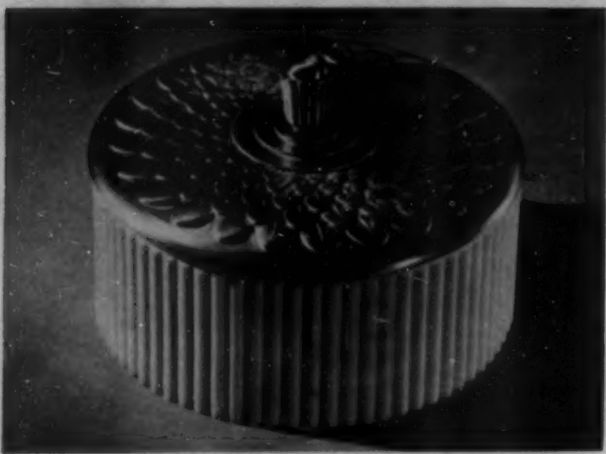
Finished moldings of urea materials are chip-, rust- and corrosion-proof, and possessed of a smooth surface and high luster. They may be tapped, drilled or subjected to any common machining process, but machining of the surface should usually be avoided, due to the possibility of checking after long periods of use. Inserts are often molded into the finished piece, but sufficient material should be allowed around the insert to accommodate dimensional changes in the metal.

An immediate shrinkage of .004 to .011 in. per in. takes place in urea castings on cooling after being removed from the mold, followed by a further shrinkage up to a maximum of .014 in. per in. *from mold dimensions*. When close tolerances must be held, carefully controlled fabrication is necessary.

Another unique characteristic of urea materials, particularly of interest to the electrical industry, is their resistance to surface arcing, and the fact that any carbonized surface which may be formed is non-conducting. The *Properties Chart* which includes electrical properties (at the end of this section) will prove interesting to an electrical engineer, but a further discussion of the properties is not in place in a general article of this nature.

The natural, unpigmented compound is highly translucent, giving high light transmission with an exceptional degree of diffusion. This characteristic makes the material ideal for semi-indirect lighting diffusors where a balanced distribution of illumination is desired. The addition of pigments to the material cuts down the transmission of light, but increases the reflection factor, thus making available for illuminating bowls and diffusors a range of translucency from high transmission to high reflection with no impairment of the overall lighting efficiency. The following figures illustrate the efficiencies of various materials, (*Please turn to page 104*)

This 26½ in. Wakefield illuminating bowl has become famous because it provides a urea lighting fixture of extraordinary size compared to weight. Molded of Plaskon by General Electric. The lighting fixtures below are from Chase Brass and Copper Co.'s new *Midas* line molded of Beetle by Waterbury Button Co. The Wells-Gardner radio at the right is a new model molded of ivory Beetle by Chicago Molded Products Corporation



Diversified uses of urea molding compounds are well expressed in these four illustrations. Top—Candy box of Beetle molded by Plastic Molding Corp. In-betweens—Teck-Lite safety switch plate molded by Windman Bros. and the Autopoint Co.'s Autodex telephone-number-finder molded by Accurate Molding Co. Both are of Bakelite urea. The Francisco Auto Heater at the bottom was molded of Plaskon by Recto Molded Products Corporation

(*Continued from page 100*) in a molding .047 in. thickness:

	Light Reflection	Light Transmission	Total Efficiency
Highly translucent	50	39	89
I.E.S. approved diffusing	59.3	32.6	91.9
Semi-opaque	68.7	22.4	91.1

These properties of illumination, plus the lightness of weight and shock resistance of the material have brought it widely into use in the illuminating industry. Diffusors are molded for I.E.S. study lamps which easily meet the rigid specifications covering such features as surface brightness, total light output and a balanced distribution of that output between reflection and transmission. Similarly, molded bowls have found ready acceptance in the indirect and semi-indirect lighting fields (bowls up to $26^1/_2$ in. in diameter have given proven service over a period of several years), and the many advantages of the strong, light weight transmitting material have been adopted for transportation illuminating fixtures, and domestic and decorative lighting.

Although urea materials have no softening point, and do not discolor on exposure to light, there is some tendency toward opacification when they are heated continuously above 167 deg. F. Occasional exposure to temperatures not exceeding 250 deg. F. is permissible. Hence when considering these materials for illuminating uses, or for any application where temperatures above those listed are likely to be encountered, engineering problems should be carefully considered.

The number of applications for urea compounds is legion, and today's list would be out of date tomorrow in any event. Mention should be made, however, of a few diverse applications for which these materials are used, indicative of their versatility.

Buttons and buckles of extraordinary resistance to the most rigorous laundering processes might head the parade of uses, followed by the many millions of vari-colored closures in such wide use in the packaging of perfumes, cosmetics, liquors and medicinal preparations. Molded boxes for jewelry, watches and other small items of high intrinsic value are the rule rather than the exception in any jeweler's window.

Housings, from those made for tiny thermometers to large radio, scale and meat chopper casings take advantage of the many unique characteristics of the urea compounds. Worthy of note is the pure white, eleven piece assembled housing on the latest model of the Toledo Guardian Scale. This type of built-up housing is ideal for encasing any mechanism of irregular design, but can in fact be adapted to practically any shape.

Few indeed are the industries which cannot satisfactorily adapt urea plastics to some product, taking advantage of their brilliant, permanent coloring, their lightness, their translucency or any of the physical characteristics which make them so universally accepted. The manufacturers of urea compounds, and any fabricator, offer full cooperation in deciding the suitability of these materials for any projected use.

Plastic color is more than skin deep—it goes all the way through. That is reason enough why more of it should be used in equipment like this which is handled almost constantly in use. The telephone pictured is molded of Tenite

COURTESY TENNESSEE EASTMAN

USING PLASTIC COLOR

by FRANKLIN BRILL

"UP IN HARLEM, THE NEGROES WEAR SOME wonderful colors. Warm browns, rich blues and greens. They're grand colors for men's suits."

Thus writes Elizabeth Hawes, leading American dress designer, in her book "Fashion is Spinach." Her analysis of businessmen's preference for somber grays, tans and black in clothes applies as patly to the colors they put on manufactured products. And the reason they avoid colorful clothes and colorful products is simply that they don't know enough about color to take a chance.

That this color conservatism is not shared by the American shopper is shown by the sales of gaily colored home furnishings—china, kitchenware, draperies, linens and towels. And since these same gay and popular colors are available in many plastic materials, it would seem that manufacturers who use molded parts are missing thousands of opportunities to use color on their products and packages to attract more attention, to open more purses and to make the use of their product seem more like fun than work.

As any designer instinctively knows, color has the property of conveying emotional reactions to the observer. Thus, reds, oranges and variations of these colors convey a feeling of warmth; blues and greens are cool. (Laundries and bakeries have repeatedly reduced complaints of heat by painting walls in light ice-blues; and it is an old rule of the theater never to play a comedy scene under anything but yellow light.) In fact, various colors can make a product look larger, smaller, heavier or lighter; rich, soothing, expensive, hot, cool, clean, strong or stimulating. Such color reactions should be studied before approaching any color selection job, for while they are by no means infallible they cannot be ignored without leading to the selection of colors


WURLITZER AUTOMATIC PHONOGRAPH MODEL 600

COURTESY BAKELITE CORP.

which are unsuited to a product's function. These connotations are listed in table form elsewhere in this article.

Another peculiarity of color is that different tints, shades and intensities of a given color will produce different emotional responses. For example, a light green will have a fresh clean look; a dark green may look unhealthful or cheap. Pink—which is red with white added—will look delicate, where red will look strong and exciting; while brown—really a dark orange—produces a different reaction than its parent color. Thus, selection of proper colors can do much to suggest the quality of a product.

Products on which colored plastics are used or could be used, fall into several classes—each class with its color possibilities and taboos. One group might be called House Furnishings, and would include telephones, lamps, door knobs, furniture and the like. Here one has so many restrictions that it is easy to see why ivory urea moldings are popular—they harmonize with everything. Nevertheless, other pastels and grayed colors and the more subtle in-between blends can often be used more effectively—especially on higher priced products. In this respect we might note the results of some of Dr. Winch's color preference tests on savages, children and adults which show a desire among the first group for bright garish colors and a similar leaning among children, but a decided preference for softer tints and shades among adults. Which indicates that civilization refines our color tastes and that among higher incomes one is likely to find subtle color schemes most popular.

As we mentioned, coloring this house furnishing group involves several problems, for it is obviously impossible to put a bright blue clock or telephone in the average home because of clashes with room colors. Nevertheless, well chosen pastel colors can often be used because the predominance of white in all pastel colors reduces the possibility of color-conflicts. The same holds true of colors which are toned down by the addition of gray. This fact is borne out by Stromberg-Carlson's successful experience with soft grayed acetate colors on their telephone sets, explained by the fact that a soft grayed or whitened green, for instance, will harmonize with any green, brown, orange or yellow—light or dark, bright or dull—which may happen to be used for accents or base colors in the room.

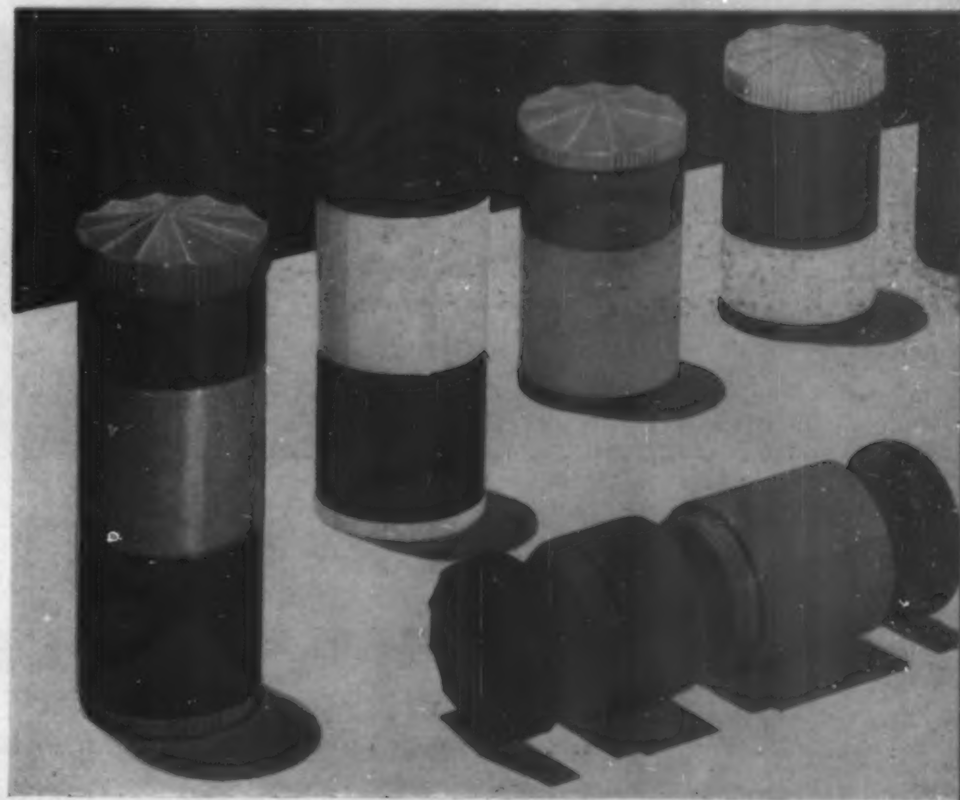
Somewhat different reasoning can be applied to that group of products known as Home Appliances; toasters, coffee-makers, kitchen-mixers, irons and ironers, vacuum cleaners and the like. Because such products employ plastics for trim or components only, and because they

are not generally enough in use to be considered part of a kitchen or breakfast-room color scheme, the lid may well be taken off on bright gay colors. Furthermore, gay colors on such appliances make their use seem more like fun than work and danger of color conflicts is always reduced when bright colors are used in small areas, such as handles, small hoods and decorative trim. Silex coffee-makers have shown the popularity of gay red molded handles, trays and sugar-and-creamers—and probably the only reason that black Silex models are still leading in sales is because so many coffee-makers are bought as wedding gifts and the givers prefer to play safe rather than take a chance on the bride's color-preference. Incidentally, Silex credits much of their success to the preference that display men give their scarlet set over drab-colored competitors.

This experience of Silex should give inspiration to manufacturers of some of the other appliances listed in this group. For example, a vacuum cleaner with rich gray molded parts, perhaps in two tones, set off by brilliant scarlet molded handles, hood or trim, would probably be as smart and popular as was that gray and scarlet Ford convertible roadster of a few years back. Or an electric toaster in rich brown and chromium with scarlet cast phenolic handles might well get the breaks in window displays and counters and as a gift item. Again, electric mangles or ironers might emphasize their ability to keep the operator cool by using ice-blue molded handles and controls and name plates, just as Sears have done with their Coldspot refrigerator. A similar trick with an ordinary electric iron would probably work with reverse English to the detriment of the sponsor's sales by reflecting on the iron's ability to get really hot. Random theories of this type, however, should always be checked by market surveys before adoption—of which more later.

On molded products such as range timers, kitchen clocks, kitchen gadgets and other products which stay put and must fit the room's decorative scheme, manufacturers should watch the progress of the National Retail

Four types of colored plastics on the opposite page suggest typical uses for each. Polystyrene is transparent but may be pigmented or dyed in any color and is the least inclined of all the plastics to absorb moisture. Phenolic is usually colored black or dark shades of red, green and brown because lighter shades are inclined to yellow. Urea, being water-white before it is colored is available in every shade. Pastels are particularly popular. Cellulose acetate is another plastic which can be obtained in almost any shade of color as well as clear transparent. Those illustrated are of Bakelite. Cosmetic jars on this page are of phenolic (Durez) and urea (Plaskon) combined. Dedon cases are ivory and blue urea



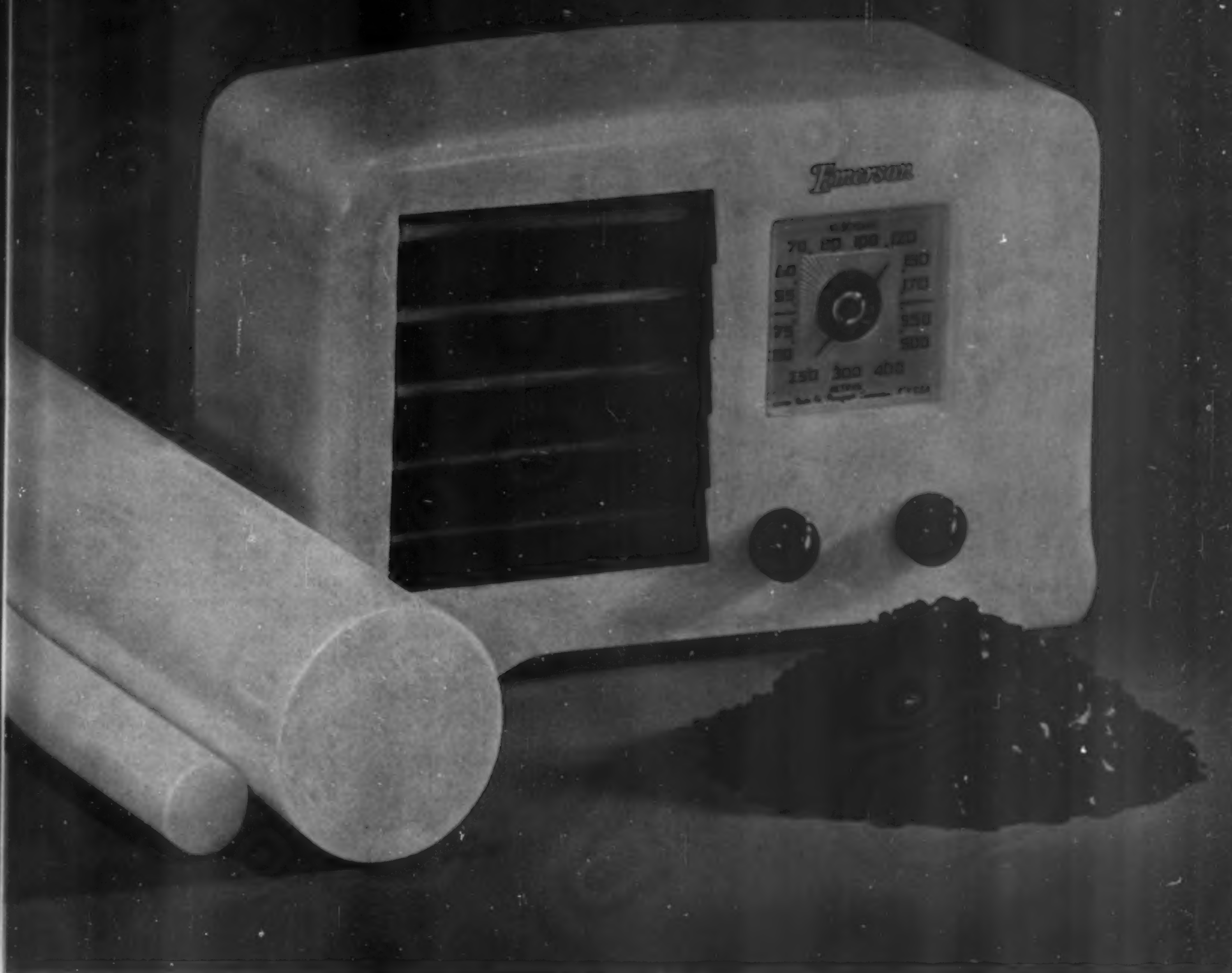
COURTESY PLASKON CO.

IF CAST PHENOLICS *plus* MOLDING
WHY NOT LET MONSANTO

Time was when a radio cabinet made from a single plastic material was news. But today's cabinets combine different ones for greater beauty and added sales persuasion. Emerson Radio and Phonograph Company, for example, one of the manufacturers using Monsanto Plastics, houses its model AX-235 in cabinets cast from Monsanto CP with the controls and grille molded from Monsanto CA.

A superior product must look the part. Progressive manufacturers in all fields now recognize the advantage of lifting their carefully engineered products above the commonplace, in appearance as well as in performance. No doubt you are constantly considering new ways of making your own product stand out from the crowd, and if so, undoubtedly you have thought of plastics, because plastics have caught the imagination of the buying public and are in demand.

If you have never investigated the use of plastics in your products, or if you have new problems involving design of your present


Emerson

Dry Goods Association's standard kitchen and bathroom colors. These ten colors replace the thousands formerly used, and make it possible for a red-trimmed clock to match accurately the red trim on stoves, cabinets, tables and appliances. This guarantee of accurate matching provides new sales angles and display tie-ins, and even though older kitchens might not have many pieces in the new colors, manufacturers using them can be sure at least that the colors have a tested and proven appeal.

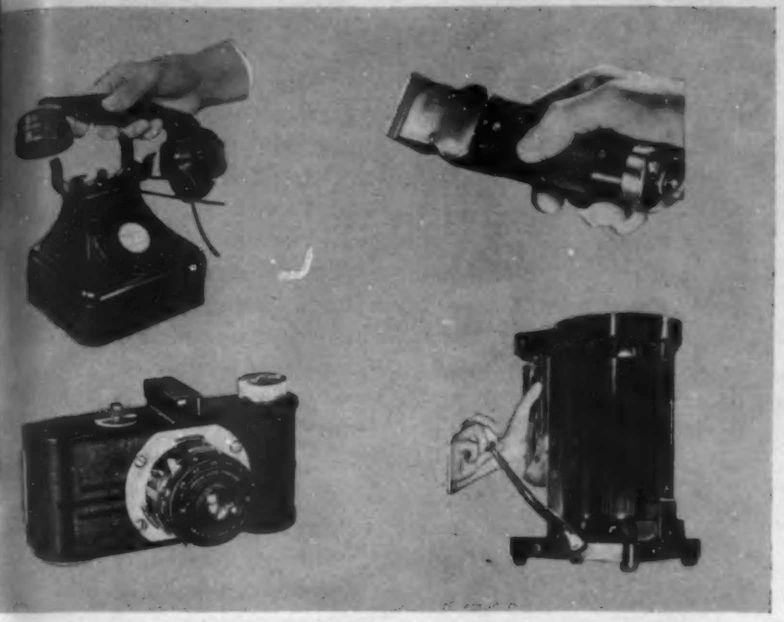
In between these groups are several products which call for special consideration. Radio cabinets are one. Because they must harmonize with all sorts of living rooms and bedrooms, most manufacturers play safe with black, mottled browns and ivory; yet soft grayed or whitened plastic colors can be used as a foil for brightly colored trim and still blend (*Please turn to page 172*)

COURTESY DUPONT

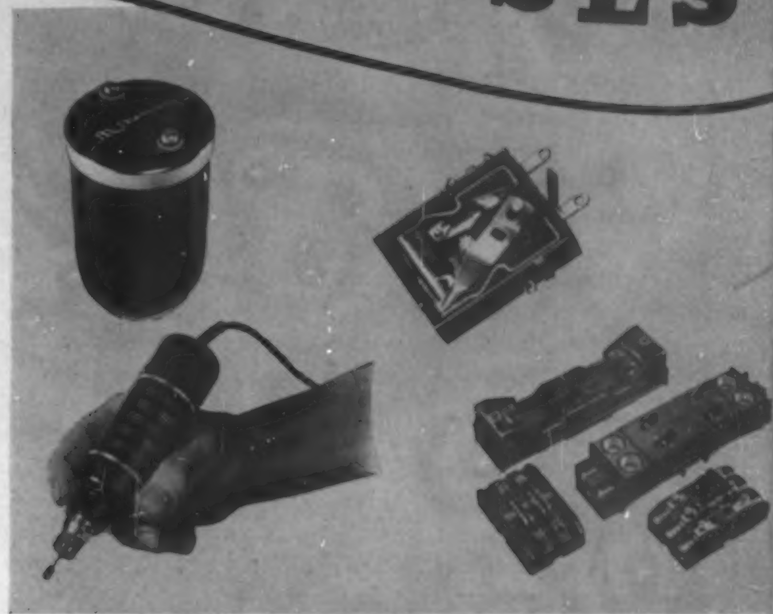
Cellulose nitrate has long been used for dresserware. Beautiful colors and configurations are especially created for this purpose. The set at the left is "Celestial," created in Pyralin by du Pont. The illustration below, taken from a recent advertisement of the Celluloid Corp., shows dramatically what a difference color makes. It also pictures typical uses of Lumarith, a cellulose acetate molding compound

COURTESY CELLULOID CORP.

INTO SALES SUCCESSES



DUREZ IS STRONG AND DURABLE, YET LIGHT IN WEIGHT. Look at your telephone...lift it, then just *try* to break it. Durez instrument cases are used for airplanes—and each of the four mounting lugs must withstand a breaking-pull test of 175 pounds. Heater housings, binoculars, chair arms and cameras are molded of Durez. Properly designed Durez cases and housings are unbelievably strong for their weight.



DUREZ HAS GREAT DIELECTRIC STRENGTH. (Up to 1000 volts per mil.) Wires and connections can be molded right in the housing, Durez itself supplying necessary insulation. Electrical parts made with Durez have good arc resistance, and can be used for high-tension ignition service. Distributor heads, motor housings, sockets, switchboards and push buttons are made of Durez.

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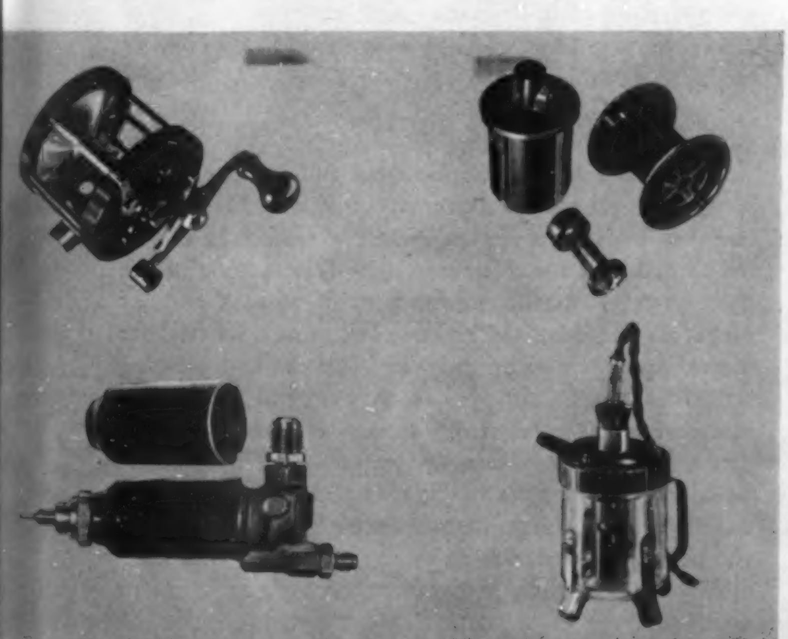

DUREZ IS INERT TO CHEMICALS, IS UNAFFECTED BY WATER, HEAT AND STEAM. The rayon industry uses Durez to make spools, frames and a host of other parts that must be chemically inert. Marine hardware, electrical fittings and fishing-reel housings are made of Durez to withstand the corrosive action of salt water. Durez is the only plastic that could remain immersed in the boiling, medicinal fluids of this vaporizer.

DUREZ IS FORMED AND FINISHED IN ONE OPERATION. Durez products come out of the mold complete with lugs, inserts, flutes, trade-marks, decorations and the final surface finish. Only slight buffing to remove fins is required. Durez products vary in size from a vest-pocket pillbox to the huge case of a complicated statistical machine. They are simple as a cap for a toothpaste tube, complex as an entire camera, complete except for shutter and lens.

It is the function of the Durez organization to assist manufacturers in determining the practical application of Durez molding compounds to their products. For further data consult your custom molder or write to us for descriptive literature and the advice of our technical staff. General Plastics, Inc., 210 Walck Road, North Tonawanda, N. Y.

Free on request, complete booklet of the many applications, uses and properties of Durez molding compounds.

DUREZ
MOLDING COMPOUNDS

SEE DUREZ ADVERTISEMENT ON PAGES—38-39

VINYL PLASTICS

by GEORGE C. MILLER

DURING RECENT YEARS THE USE OF PLASTICS has increased tremendously, the development of materials for new and wider uses having been both a cause and a result of the rapid expansion of the industry. The list of commercially available plastics is already long and no doubt somewhat confusing to many users and prospective users of these materials. In the following discussion we shall attempt to explain briefly the manufacture, form, properties, fabrication and uses of commercially produced vinyl resins, a group that has assumed an important place in this fast growing industry.

Vinyl resins have been known for many years, but only within the past few years, through the enterprising spirit and skill of expert technicians, have these resins been developed from laboratory curiosities into vital and essential factors in industry. Vinyl resins are polymerization products, that is, the polymers are formed by self addition of the monomer to form a chain molecule. They are thermoplastic, i.e., under heat, they do not undergo chemical changes which result in infusible and insoluble substances. Among other general characteristics are toughness, clarity, non-flammability, and lack of odor, taste or toxicity.

Polyvinyl acetate

Vinyl acetate, a clear liquid boiling at 72 deg. C., is converted to resinous polymeric form by polymerization with a suitable catalyst. The resin may be produced in various viscosities by varying reaction conditions, the softening point increasing and solubility decreasing as molecular weight is increased. An intermediate viscosity resin is readily soluble in ketones, esters, chlorinated and aromatic hydrocarbons and alcohols, but insoluble in water, aliphatic hydrocarbons, fats and waxes. It is compatible with nitrocellulose and to lesser degree with shellac, dammar, rosin and ester gum.

The resin, which is supplied commercially in granular form, about ten mesh, is odorless, colorless, tasteless and non-toxic. It is being used in ever-increasing quantities for many important industrial applications. One of the most important uses is in the adhesives field where the thermoplastic nature of the resin and its exceptionally strong bond to almost any type of surface make it especially well suited to rapid mass production of many types of fiber cartons that must withstand hard service. Examples are milk cartons, oil cartons, drinking cups, ice cream cartons, and cartons for quick frozen food products. In production of fiber containers the resin in solution form is applied to carton stock and the solvent evaporated, after which the seams of the container are quickly heat sealed during fabrication. The lower viscosity resins may be applied as a hot melt, without the use of solvents.

Polyvinyl acetate is used in quantity for mixing with wood fillers and solvent to provide wood putty in a wide variety of colors, this material drying with practically no shrinkage, providing sections which may be sawed, nailed, planed, or otherwise worked as wood. The resin is well suited, either alone or mixed with nitrocellulose, as a shoe cement, or for the cementing of sheet material around wooden heels of women's shoes. Because of its tendency to cold flow, the material is not suitable for molded objects unless appreciable amounts of reinforcing fillers are used. The filled material, however, may be molded by either the compression or injection process, and is being used in quantity for molding advertising novelties and period reproductions of intricate design.

Due to the zero acid number of polyvinyl acetate, its rust inhibiting qualities, great stability to ultraviolet light and freedom from oxidation, it makes an excellent vehicle for metallic paints. The clear solutions are especially well adapted for preserving the natural finish of stone, bronze and similar surfaces. Other important uses are: sealing of glass brick, manufacture of non-aqueous gumming tape, sealing metal foil to paper or cork backing, sealing of leather or cellulosic films, and providing oil-proofness, increased transparency and washability to many types of papers. In certain types of applications where an extremely flexible or tacky coating is required, plasticizers may be used to advantage. In such cases various of the phthalates, tartrates, glycollates and phosphates will be found suitable.

Some of the physical properties of polyvinyl acetate are listed in Table I. (*See page 118*)

Vinyl acetals

While the number of applications and tonnage figures for polyvinyl acetate have mounted steadily during recent years, it now begins to appear as though one of the largest uses for this material will be as one of the base materials in the manufacture of vinyl acetal, or vinyl acetate-aldehyde resin. The vinyl acetals are formed by hydrolyzing polyvinyl acetate and treating with an aldehyde, thus replacing part or all of the acetate groups of the polyvinyl acetate with the aldehyde. The resin is produced as a white granular thermoplastic powder, the properties varying with the aldehyde used, the viscosity of the polyvinyl acetate base material, and the percentage replacement by the aldehyde. The acetaldehyde, formaldehyde and butyraldehyde replacement resins are now being produced on a commercial scale.

The acetaldehyde replacement resin may be produced from polyvinyl acetate of a wide range of viscosities with a wide range of replacement by the aldehyde. A representative resin of the acetaldehyde replacement type is odorless, tasteless, somewhat yellow in color, slow burn-

TABLE I

Specific Gravity	1.191
Tensile Strength	Approx. 5000 lbs./sq. in.
Refractive Index N_D	1.4665 @ 20°C.; 1.4483 @ 80°C.
Burning Rate	Slow Burning
Electrical Properties:	
a. Dielectric Strength (Approx.)	1000 V/mil in air @ 60 cycles
b. Surface Resistance Ohm Cm.	$>10^{12}$
c. Dielectric Constant 1000 cycles	30°C.: 2.7; 60°C.: 6.1
d. Power Factor 1000 cycles	0.025 (30°C.) 0.070 (60°C.)
Aging	Unaffected
Light Stability	Unaffected by direct sunlight
Heat Stability	Unaffected at 200°C. 1 hr.
Viscosity (Percent solids required to give a viscosity of 110 ± 10 centipoises @ 20°C. in methyl isobutyl ketone)	Resin AYAA.................27½% Solids Resin AYAF.................21% Solids Resin AYAT.................18% Solids
Initial Heat Distortion Point (A.S.T.M.)	Approx. 38°C. for all above grades
Heat Sealing Temperatures	AYAA.......................Approx. 105°C. AYAF.......................Approx. 130°C. AYAT.......................Approx. 150°C.
Water Absorption	2% in 144 hrs. Increases on longer immersion.
Water Immersion	Swells, becomes leathery and pliable when large amount of water has been absorbed. Surface unaffected after drying.

ing, excellent as to heat and light stability, has about 2 percent water absorption (A.S.T.M.), and zero acid number. The coefficient of linear expansion is .000065, dielectric strength 1000 volts/mil, specific gravity 1.14 and refractive index 1.446. The resin is soluble in the same list of solvents that are given for polyvinyl acetate, although the solution viscosity is considerably higher than an equivalent amount by weight of polyvinyl acetate. The resin, usually with suitable fillers, may be sheeted, extruded or molded. Fabricated forms may be drilled, stamped or machined.

The formaldehyde replacement resins are made by essentially the same process as the acetaldehyde types, except that formaldehyde is used to replace acetate groups in the polyvinyl acetate. The resin is odorless, tasteless, almost colorless and has good light and heat stability. Some other properties of a representative grade are: zero acid number, water absorption 1.3 percent (A.S.T.M.), dielectric strength 1000 volts/mil, refractive index 1.50, specific gravity 1.11, tensile strength 8000–10,000 lbs./sq. in. The resin has a higher softening point, and is considerably tougher and stronger and of lower solubility than a corresponding acetaldehyde replacement material. It is soluble in but a few materials such as dioxan, acetic acid, ethylene dichloride, trichlorethylene, and tetrachlorethane, and is resistant to alcohol, coal tar solvents, petroleum solvents, vegetable oils, glycols and water. It is gelled by some of the organic esters, such as methyl or ethyl acetate. The softening point of most grades of formaldehyde replacement resins is high enough to require a plasticizer for working the material with standard equipment.

Of the various vinyl acetals that have been thus far produced, the butyraldehyde replacement resin is by far the most important from a commercial standpoint. This resin is produced in much the same manner as the other vinyl acetals that have been above described, and in common with these resins the properties of the butyraldehyde type can be made to vary over a wide range to meet specific industrial requirements. Thus far the only grade of butyraldehyde replacement resin that is being produced in quantities of real commercial importance is the safety glass grade. This particular grade is of real industrial significance in that it seems destined to fill a long felt need for a more nearly ideal safety glass plastic. Prior to the advent of vinyl butyral plastic for safety glass, cellulose nitrate and cellulose acetate were utilized as the center sheet for the greater portion of all laminated glass. While laminated glass made with cellulosic plastic center sheets filled a great need, it also had its drawbacks, such as: tendency of plastic to shrink and crack at edges due to loss of plasticizer, considerable embrittlement at low temperatures, moisture absorption at edges making laborious edge grooving and sealing at the factory a necessity. By way of comparison, some of the characteristics of laminated safety glass, made with safety glass grade of vinyl acetate-butyraldehyde resin are as follows: the sheet plastic is merely placed between two sheets of glass and heat and pressure applied—no adhesive is required for cementing to the glass, no edge sealing is necessary. The new laminated glass is much more elastic than former types, and is about ten times as resistant to rupture at zero deg. F., and three times as resistant to rupture at 110 deg. F. The heat and light stability of the

PLASTICS . .

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vinyl safety glass resin is exceptionally good and colored automobile glass need not be used to protect this unusual material from the actinic rays of the sun.

Properly plasticized and lubricated, this resin may be calendered, extruded, molded and otherwise processed with equipment standard in the plastics industry, to provide various articles of great strength and low unit weight. Some solvents for the resin are methanol, ethanol, isopropanol, butanol, cellosolve, methyl and butyl cellosolve and dioxan. It is not dissolved but is swelled by the ketones, aromatic hydrocarbons, organic esters and chlorinated hydrocarbons. Diethyl phthalate and 3-GH are satisfactory plasticizers. Some of the physical properties of the safety glass grade of resin are given in Table II.

TABLE II

Specific Gravity	1.11
Tensile Strength lbs./sq. in.	8100–8500
Notched Impact ft. lbs./specimen (.5" x .5" bar .1" notch)	.44–.60
Modulus of Rupture—lbs./sq. in.	11,400
Heat Distortion Point (A.S.T.M.), °C.	57–58
Water Absorption—16 hrs. @ 60°C.	3–5%
Resistance to alkalies	Moderately good
Resistance to acids	Poor

Polyvinyl chloride

Since it adequately fills many industrial needs, the requirements of which are not met by any other material available, the scope of polyvinyl chloride resin has been greatly broadened and volume used has increased steadily over the past few years. This useful resin results from the polymerization of vinyl chloride with a catalyst, and it may be produced to various degrees of polymerization, or molecular weights. It is a granular powder, somewhat cloudy, odorless, tasteless, non-burning, and has a comparatively high softening point. Specific gravity is 1.4, and refractive index at 20 deg. C. is 1.544. Water absorption is extremely low and the resin has great resistance to corrosive materials, such as sulfuric, nitric and hydrochloric acids, and alkalies. The resin, particularly the high molecular weight variety, is only slightly soluble in ordinary solvents at room temperature, but is readily soluble at elevated temperatures in such materials as dioxan, mesityl oxide, chlorinated hydrocarbons, tricresyl phosphate, dibutoxy ethyl phthalate, 3-GH and dibutyl phthalate. If the application requires use of the material in a liquid state, it should be used at a temperature near the boiling point of the solvent, as the solution tends to set to a gel upon cooling.

Plasticized polyvinyl chloride may be calendered, extruded, molded, stamped, sawed or drilled, and has found wide usage in many fields requiring a resilient, rubber-like non-oxidizing material that is unaffected by acids, alkalies, oils, fats and water. Since the material is thermoplastic, all flash trimmings or rejects may be reworked a considerable number of times with no appreciable effect on the properties of the resin. Some of the industrial applications for which plasticized polyvinyl chloride has proven especially suitable are: matrix material replacing glue-glycerine compositions for molding of plaster of Paris articles, gasket material for flanges on medium pressure oil lines, extruded coatings for low voltage cables and wires, covering for temple rolls in the textile industry, coatings for plating racks, and as a highly chemical-resistant coating on paper or cloth.

Copolymer

For electrical transcription records, slide rules, dentures, bottle closure liners, plating tanks and racks, food can linings, starchless collars, textile sizing, thermoplastic adhesives, insulating tape, extruded cable coatings, floor tile—one would guess that many different plastics would be required. The above, however, is but a partial list of many widely diversified applications, the exacting requirements of which are being successfully met with what is undoubtedly one of the most versatile of plastics—the vinyl acetate-vinyl chloride copolymer resin.

Vinyl acetate-vinyl chloride copolymer resins result from the conjoint polymerization of the monomeric materials in the presence of a catalyst. The properties of the resin can be varied widely by the degree of polymerization and by the ratio of vinyl acetate to vinyl chloride. Development work on many applications has indicated that the 87 percent chloride—13 percent acetate grade is suitable for the widest range of usage. This grade is manufactured in various molecular weights; the high molecular weight for high impact molded articles and sheet stock, the intermediate molecular weight for paper coating, solution coating and injection molding, the low molecular weight for giving higher solids content and improved flow-out in surface coating formulations. Some physical properties of an intermediate molecular weight copolymer are given in the Plastics Properties Chart at the end of this section.

Compounding—Copolymer resin is compounded with standard types of mixers and rolls such as are used for compounding of rubber mixes. The usual procedure is to dry blend filler, coloring materials and resin prior to Banbury mixing or milling. The mix becomes soft and somewhat sticky when hot so 1 percent to 2 percent of lubricant, such as a carnauba wax, should be used. It is also advisable to use a small amount of a heat stabilizer, such as lead stearate, lead oleate, litharge or calcium stearate, since the thermal life of the resin is not unlimited, especially in contact with iron at elevated temperatures. Equipment temperatures from 200 deg. F. to 300 deg. F., depending on amount of filler or plasticizer used, are generally satisfactory, and usually not more than ten minutes compounding is required for thorough mixing.

A number of fillers are satisfactory for compounding with copolymer resin. Examples are: clay, talc, super floss, slate flour, mica, asbestine, carbon black, blanc fixe, woodflour and cotton linters. If a plasticizer is required to obtain additional flexibility for a specific use, a number of the phosphates, glycollates, and phthalates will be found satisfactory. (*Please turn to next page*)

(Continued from preceding page)

Molding—Copolymer resin, filled and unfilled, is molded from powder, compressed preforms, or preforms cut from sheet or rod stock. For orthodox compression molding a steel mold is required, properly cored for alternate heating and cooling. Molding temperature is 275 deg. F. to 300 deg. F. and the casting is cooled to about 90 deg. F. before molding pressure is released. A semi-positive mold and pressure of about 2000 lbs./sq. in. total cross section area of casting, is required for best results. Copolymer resin of the proper grade may be molded by the injection process with standard types of machines now on the market. However, since the resin undergoes some color change when subjected to prolonged heating, it is necessary for best production results to chrome plate all parts of the machine with which the hot material comes in contact, except the mold. Also the resin should remain in the heating cylinder for a minimum length of time, therefore heating cylinder design should be such that no blocking of the resin in the cylinder can occur. Copolymer resin is almost colorless as produced, therefore pastels of any degree of translucency are easily obtained. The resin is odorless, tasteless, non-toxic, has practically no warpage or shrinkage, is non-flammable, highly resistant to water, acids, alkalies and alcohols. These excellent properties in a single resin make it desirable for many industrial applications, such as: dentures, cosmetic and food containers, bottle caps, radio parts, automobile and refrigerator parts, fountain pen barrels, steering wheels, transcription records, plating tanks, storage battery parts, toothbrush handles, etc.

Calendering—Copolymer resin with or without filler, is well adapted to calendering with standard type of rubber machinery. The compounded stock is transferred hot from the mixer or mill roll to the calender and a continuous sheet of .002 in. up in thickness is produced. Calender temperatures are from 200 deg. F. to 300 deg. F. depending on the plasticity of the mix. Films may be calendered onto paper and cloth with the regular calender equipment. Some of the many uses for calendered stock alone or on paper or cloth include: film for laminating cloth, wood or paper, tape insulation, clear coating for printed matter, coated paper for bottle cap liners, coated cloth for artificial leather, rough sheets for polishing or for molding preforms.

Sheets, Rods and Tubes—Copolymer sheet stock is exceptionally well suited for an ever-increasing number of uses, such as: slide rules, calendar cards, radio dials, playing cards, loose-leaf binders, automobile sun visors, battery separators, decorative effects and many others requiring a non-flammable, non-shrinking, highly resistant and durable material. Sheets may be in any color, any degree of translucency, with mat or polished surface.

Tubes and rods may be extruded in various shapes and cross sections for fountain pen barrels, liquid dispensers, condenser shells, molding preforms, cove molding and similar articles. Copolymer resin is extruded over wire at high production speeds with standard equipment to provide a very tough, flexible and extremely corrosion resistant coating with excellent electrical properties.

Surface Coatings—Many a tough coating problem has been solved by lacquer formulators within the past year or so with copolymer vinyl resin. A few examples are: interior linings for cans to package beer, fountain syrups, shortening, soap solution and bleaching solution, and as the coatings for cement wall board, swimming pools and metal foils. The toughness, durability, elasticity and imperviousness to water and corrosive agents in general, of copolymer resin, make it admirably suited for these and many other uses where a tough, durable finish is essential. Solvents are ketones, chlorinated hydrocarbons, esters and poly-ethers. The two former give the highest resin concentration in mobile solution. Because of some toxicity of chlorinated hydrocarbon solvents, ketones are preferable as the active solvent. Examples are: acetone, methyl ethyl ketone, methyl isobutyl ketone, methyl n-amyl ketone, acetonyl acetone. Coal tar solvents, such as toluol and xylol, may be used as diluents, in quantities from 40 percent to 90 percent by weight of total solvent, depending on resin concentration desired. Use of alcohol in thinner should be avoided as a small amount will precipitate the resin. For highly flexible coatings, a number of plasticizers will be found satisfactory, such as tricresyl phosphate, dibutoxy ethyl phthalate, 3-GH, and some of the Santicizers and Aroclors.

The resin is "cold cut" in solvent or solvent diluent mixtures in a closed mixer, with vigorous agitation of the mix. Pigmentation is best accomplished by adding a pigment paste to a clear base solution with vigorous stirring. Pigment paste is prepared by first milling a comparatively high ratio of pigment to resin on a two roll mill, subsequently dissolving chips in solvent to provide the high viscosity solution, or paste. Copolymer finishes are of the baking type and are applied by spraying or roll coating. Since the resin tends to change color if held at elevated temperatures for extended periods, the usual precautions with regard to incorporating proper heat stabilizers must be observed. Use of proper stabilizer is of particular importance where the surface to be coated is one that tends to accelerate resin decomposition, such as iron or zinc.

Conclusion

The plastics industry today is comparatively small when judged by "big business" standards and might well be compared to the automobile business of about 1900. Judging from the present interest in and demand for plastics, it seems quite possible that the plastics industry may experience the same sort of expansion we have seen in the motor car and electric refrigerator fields. Raw materials for plastic manufacture are to be had in practically unlimited quantities at reasonable cost, plastic manufacturing costs can be expected to decrease steadily as volume increases and there is an increasing demand for plastics to fill new and wider uses. The vinyl plastics are especially well situated to maintain leadership in this advance, due to their great versatility and certainty of lower costs as volume continues to increase.

When the new vinyl acetal resin comes from the dryers it is packed in steel drums to be transferred to another division of the plant where it is processed into continuous sheeting for safety glass manufacture

POLYVINYL ACETALS

(*Continued from page 62*) and composition yields the best combination of properties. Closely related to this is the still current problem of choice and proportion of plasticizer to be used with the resin.

Tests of suitable polyvinyl acetal resins by leading manufacturers and users of safety glass have indicated that as the base material for safety glass interlayer these resins offer an excellent combination of properties, superior to those of any other plastic heretofore employed. They are clear and of good color, and are resistant to the deteriorating influences of heat, light and moisture. Because of their immunity to damage by moisture the edge-sealing of safety glass panes, which has been found necessary with cellulose plastics, can be omitted; this improves the appearance of the pane and simplifies the work of the replacement dealer, who cuts special shapes from standard sheets.

In suitable admixture with plasticizers, not merely are these resins tough and adhesive at ordinary temperatures but they retain these important protective properties to an unusual degree at temperatures of winter driving, and are not unduly softened and weakened by summer temperatures. Furthermore, they satisfy the modern preference for a safety glass characterized by a "rubber bag break," i.e., one which in the event of destructive impact offers less rigid resistance than that of the earliest laminated glass, or than that of "tempered glass," being capable of yielding and bowing out and thus lessening the severity of the blow to the head or body of a passenger. The plasticized polyvinyl acetal resins have the pliability and rubber-like characteristics essential to this yielding break and also the strong adhesiveness necessary to hold the broken glass in place.

Certain of the polyvinyl acetal resins lend themselves to the formation of compounds for molding by either compression or injection. Their thermoplasticity and resistance to damage by heat makes feasible the incorporation of auxiliary ingredients—plasticizer, coloring materials, lubricants, form-stabilizers,[14] etc.—without the assistance of volatile solvent. This is done in a mixer of Banbury type[15] or on mixing rolls. In some cases plasticizer can be omitted. The homogeneous mass is cut to a granular form suitable for molding. Injection-molded articles of acetal resin have been on the market for several months past.

Some of the resins of the group can be made up into sheeting for uses analogous to those of sheeting of cellulose nitrate plastics. For this purpose the more rigid resins are to be preferred, and comparatively little plasticizer is used, or even none at all. The general technique of manufacturing such sheeting parallels that of sheeting cellulose acetate or cellulose nitrate. Such material has not yet gone far into commercial use, but further commercial development is to be expected.

(1) See trade-name Directory Section. The butyraldehyde, acetaldehyde and ormaldehyde resins of E. I. du Pont de Nemours & Co., Inc., as yet are unnamed.
(2) U. S. Patent 2,036,092 (reissue 20,430).
(3) Ind. Eng. Chem., *28*, 1130 (1936).
(4) Berichte, *60*, 1782 (1927).
(5) U. S. Patent 1,672,156.
(6) J. Am. Chem. Soc., *60*, 1045 (1938).
(7) Ellis, "Chemistry of Synthetic Resins" (1935), p. 1060.
(8) Bernthsen-Sudborough, "Textbook of Organic Chemistry" (1931), pp. 132, 136.
(9) The possibility of cross-linkages between chains can be ignored for the purposes of the present article.
(10) Ind. Eng. Chem., *28*, 1155 (1936).
(11) Ind. Eng. Chem., *28*, 1132 (1936); Staudinger, "Die hochmolekularen organischen Verbindungen, Kautschuk und Cellulose," Springer, Berlin, 1932.
(12) The apparent contradiction of the opposed arrows indicating solubility changes in the lower right hand corner is explained by the existence of a zone of maximum solubility.
(13) Canadian Chemistry and Metallurgy, August 1934; Chem. Met. Eng., *43*, 177 (1936); National Safety News, *34*, 27 (Sept. 1936); Modern Plastics, *15*, 47 (Jan. 1938).
(14) U. S. Patent 2,016,202.
(15) U. S. Patent 2,056,796.

ETHYLCELLULOSE RESINS

(*Continued from page 28*) spotted with the corrosive agent. The liquids were covered with a watch glass and the rusting or blistering was observed after 24 hours' exposure. Such a test is quite sensitive and indicates clearly the permeability of the material.

Similar films were used for evaluating hardness, which was determined by the Sward Hardness Rocker. On the Sward scale the hardness of glass is taken as 100. A composition with a hardness of 70 cannot be scratched with the fingernail.

The temperature change test consisted of heating the panels for one hour at 212 deg. F. and chilling for one hour in an ice box maintained at −15 deg. F. The change from oven to ice box was made as rapidly as possible in order to produce sudden chilling. This schedule constituted one cycle and observations were made of cracking after refrigeration.

From the standpoint of discoloration the phenolics, modified phenolics, chlorinated diphenyl and coumarone resins in combination with ethylcellulose give plastics which discolor rather badly, while the non-phenolic, natural and modified alkyd resins are much superior. In general, the resins are much more sensitive to discoloration by ultra-violet light than ethylcellulose while the resins are more resistant to water than ethylcellulose. Ethylcellulose has little effect on the acid resistance of synthetic resins and usually improves their alkali resistance. In most cases ethylcellulose has a slight hardening effect on the resins and a very marked toughening action, as indicated by the change of temperature test. This latter is probably the most important contribution of ethylcellulose to resin plastics.

The data here given refer only to ethylcellulose-resin mixtures. It is obvious that the type of resin has a controlling influence on the characteristics of the plastic made with it. In other tests it was found that the addition of small amounts of plasticizer in many cases greatly improved the toughness, but these additions were made at the sacrifice of hardness. By a proper selection of plasticizer, the sensitivity to water and acid or alkali was not decreased. These data indicate a somewhat different approach to the problem of developing plastic compositions and demonstrate new types of plastic mixtures made possible by ethylcellulose and resins.

(1) Wiggam, D. R., Modern Plastics, *14*, p. 31, October 1936.
(2) Gibb, D. A., ibid., *15*, p. 23, October 1937.
(3) Staudinger, H., and Daumiller, G., Ann., *529*, 219–65 (1937); Staudinger, H., and Sorkin, H., Ber., *70B*, 1993–2017 (1937).
(4) Mark, H., Physik und Chemie der Cellulose, p. 56–63, Julius Springer, Berlin, 1932.

TABLE I

	Discoloration by Ultra-violet Light		Sensitivity to Water		Sensitivity to 5% Hcl		Sensitivity to 5% NaOH		Hardness		Temp. Change Cycles	
Resin	A	B	A	B	A	B	A	B	A	B	A	B
Amberol 800 (non-phenolic)	V. Sl.	V. Sl.	B. Bl. B. R.	Bl. Sl. R.	OK	OK	OK	V. Sl. R.	82	78	9	2
Beckacite 1114 (non-phenolic)	Sl.	Sl.	B. Bl. R.	Bl. Sl. R.	V. V. Sl. R.	V. Sl. R.	V. Sl. R.	Sl. R.	86	82	40	2
Amberol ST 137 (pure phenolic)	B.	B.	R.	V. Sl. T. Blu.	V. Sl. R.	V. V. Sl. R.	OK	OK	76	66	50+	44
Paradura 367 (pure phenolic)	B.	B.	B. Bl. R.	Sl. Bl. Sl. R.	V. V. Sl. R.	V. V. Sl. R.	Sl. R.	Sl. R.	80	86	25	20
Rauzene N 100 (pure phenolic)	Mod.	B.	Bl. R.	T. Blu.	V. V. Sl. R.	V. V. Sl. R.	V. Sl. R.	Sl. R.	82	76	50+	35
Durez 550 (pure phenolic)	Sl.	Mod.	Sl. Bl. Sl. R.	Sl. T. Blu.	OK	OK	OK	OK	62	46	50+	50+
Beckacite 1112 (modified phenolic)	Sl.	Mod.	B. Bl. B. R.	Bl. R.	V. Sl. R.	Sl. R.	Sl. R.	Bl. R.	80	76	17	1
Lewisol 115 (modified phenolic)	Sl.	B.	B. Bl. B. R.	B. R.	Sl. R.	OK	Sl. R.	V. Sl. R.	92	90	44	5
Aroclor 5460 (chlorinated diphenyl)	B.	B.	Sl. Bl. B. R.	Sl. Bl. R.	OK	V. Sl. T. Blu.	Sl. R.	V. Sl. T. Blu.	84	76	44	29
Neville R-29 (Coumarone-Indene)	V. B.	V. B.	Sl. Bl.	T. Blu.	OK	V. Sl. T. Blu.	OK	T. Blu.	54	36	47	50+
Run Boea (Fossilized Manila Gum heated to 330°C.)	Sl.	Mod.	B. Bl. B. R.	Bl. Sl. R.	R.	Sl. R.	Dis.	Dis.	72	72	13	1
Dewaxed Batavia Dammar (Natural Resin)	V. Sl.	Sl.	Bl. R.	V. Sl. Bl. V. Sl. R.	V. V. Sl. R.	V. V. Sl. R.	V. V. Sl. R.	V. Sl. R.	82	84	35	5
Light Kauri Gum (Natural Resin)	None	V. Sl.	Sl. Bl. V. Sl. R.	Bl. Sl. R.	V. V. Sl. R.	V. V Sl. R.	V. V. Sl. R.	V. Sl. R.	72	72	50+	20
Petrex 1 (non-oxidizing modified alkyd)	Sl.	Sl.	Bl. R.	Sl. Bl. R	Sl. R.	Sl. R.	V. Sl. R.	R.	86	88	44	9

Legend for Table I

Composition of Formulas

Formula	A	B
Ethylcellulose	10	10
Resin	5	10

Abbreviations Used

V—Very
B—Bad
Mod—Moderate
Sl—Slight
Bl—Blister
Blu—Blush
R—Rust
Dis—Disintegrated
T—Temporary

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Erie Plastics service starts long before the actual molding takes place. We maintain a creative art and design staff, headed by a nationally recognized industrial design artist, that understands both the advantages and limitations of injection molding. The services of this group are available, without obligation, for either restyling an existing product or designing a new one.

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The results of this design and engineering service is reflected in the many comparatively simple articles molded by Erie that are outstanding for their beauty and unusual depth of color, and in the many so-called "impossibles" that Erie engineers have successfully adapted to the advantages of high production, low cost injection molding. As the oldest exclusive injection molder in this country, we are best suited by experience to produce your molded parts. May we show you what we have done for others?

The focal point of the new Fairbanks-Morse Console Grand Radio is the Erie Injection-Molded bezel, knob and push-button assembly. Erie developed and perfected molded bezels with glass and metal inserts.

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Delicate interlocking cores were successfully used to bring the advantages of low-cost, high-production injection molding to Curlocomb.

In the first two Modern Plastics Competitions the only injection-molded articles to win awards were molded by Erie.

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ACRYLIC RESINS

(*Continued from page 16*) the products obtained by the evaporation of organic solvents in which they are dissolved, have a specific gravity of about 1.15 and a refractive index of 1.49. Since the acrylic resin films are completely polymerized, they dry due to solvent evaporation and are not affected by oxygen or ozone.

The unusual flexibility and elasticity of these polymers are evident from the fact that films extensible in excess of 1000 percent can be obtained without the use of plasticizers. On stretching, films exhibit a certain degree of plasticity, and do not snap back to their original form, but require an appreciable length of time for recovery. The molecular weight (viscosity) of the acrylic resins has a great influence on their properties. Polymers of high molecular weight exhibit greater tensile strength and more rapid recovery after extension than do lower polymers of the same chemical constitution.

In general, the adhesion of acrylic resins to most surfaces is excellent, with the softer polymers superior in this respect. Adhesion to metal surfaces may be improved by baking. The crystal-clear color and permanence of the acrylic coatings are unexcelled. Three years' exposure to weathering and sunlight causes no discoloration, no loss of gloss, or no failure of any kind with the harder films. Acrylic resins show good heat resistance, withstanding temperatures as high as 350 deg. F. without discoloration. Only after baking at temperatures sufficiently high to cause pyrolysis, does discoloration appear. Acrylic films can be ignited with a free flame, and after ignition, burn slowly, being similar to cellulose acetate in this property.

The chemical constitution of the polymer has a great influence on the resistance of the films against water and chemical reagents. The harder resins are not affected by alkali, sulfuric acid, hydrochloric acid, or aqueous acetic acid at room temperature, and show an excellent resistance to both cold and boiling water. The softer acrylic polymers exhibit a somewhat inferior water resistance and are slightly less stable to these chemical reagents. Although the harder films are not attacked by continued boiling in water, their adhesion is somewhat reduced. Petroleum oils, gasoline, greases, and petroleum hydrocarbons do not affect the acrylic resins; they are soluble in aromatic hydrocarbons, ketones, esters, and chlorinated hydrocarbons.

The compatibility of these resins with other synthetic polymers and with natural resins is limited. Many of the acrylic polymers are rather unexpectedly incompatible with each other. They are compatible with 1/2 second nitrocellulose in all proportions, and they show a limited compatibility with cellulose acetate. The benzyl- and ethylcellulose ethers are incompatible. Ester gum, castor oil, dammar, cumar, shellac, and rosin have limited compatibilities. Other synthetic resins, including the phenol-formaldehyde, vinyl, and maleic acid types, show some compatibility; clear resinous varnishes, alkyd resins, and drying oils are incompatible. White finishes which will not discolor may be formulated by pigmentation, as the polymers possess a permanent crystal-clear color. Since the acrylic resins are completely neutral, any type of pigment may be used.

The wide range of viscosities and concentrations in which the acrylic resins are available enables them to be applied by brushing, spraying, or dipping. Their outstanding properties of crystal-clear color, non-yellowing, petroleum and oil resistance, good electrical properties, adhesion, ozone and chemical resistance, make acrylic coatings suitable for use in many fields. They may be employed as clear metal lacquers, as electrical insulation, for chemical resistant coatings, and as coatings on rubber, glass, textiles, artificial leather, lamp shades, etc.

Solutions of acrylic resins may be used as binders for various types of materials. Here, again, the permanent properties and good adhesion of these polymers are of importance. In addition, they offer the advantages of freedom from bacterial and fungicidal deterioration, and afford the possibility of a colorless transparent bond. The elasticity and extensibility of the acrylic adhesives permit their use where the bonded assemblies are subject to flexure and elongation. Wood, metals, textiles, rubber, glass, and many other materials may be cemented together by the use of these thermoplastics.

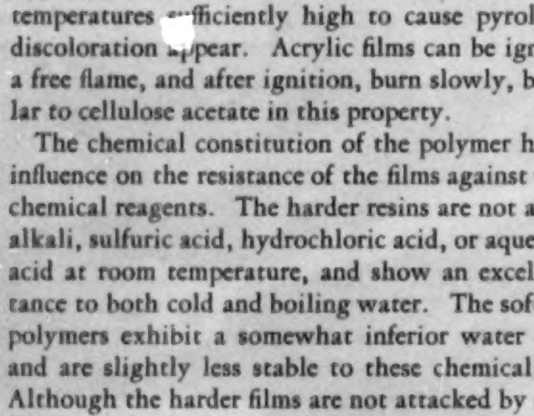
Aqueous emulsions

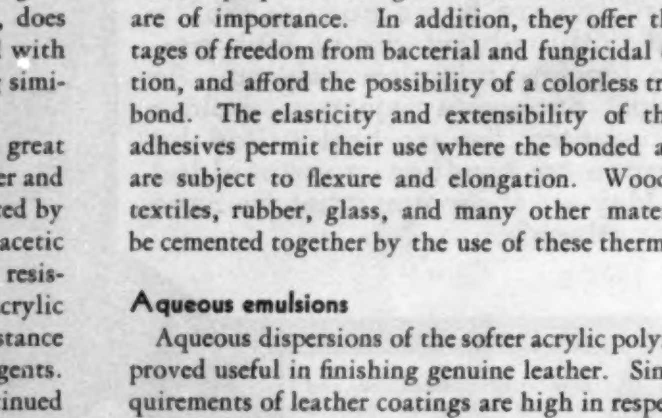
Aqueous dispersions of the softer acrylic polymers have proved useful in finishing genuine leather. Since the requirements of leather coatings are high in respect to permanent flexibility and adhesion, many coating materials, which are successful in other industrial applications, fail in this particular field.

The coatings, frequently pigmented, are applied to the grain of the leather by hand. The resulting finishes have

Cohn & Rosenberger, Inc., take advantage of the crystal clearness and light weight of acrylic plastics by making jewelry of Lucite. Rods, sheets and tubes of the material (right) indicate the variety of cast forms in which it is available

(PHOTOS COURTESY DU PONT)





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outstanding flexibility and adhesion without in any way detracting from the natural "feel" and appearance of the leather. The preservation of the natural character of genuine leather is as important a requirement as the other necessary physical properties of a leather coating.

In the textile field, aqueous dispersions of the acrylic polymers are used as permanent finishes, stiffening and increasing the tensile strength and wear resistance of the impregnated fabrics. They require no baking, give striking effects when used in low concentrations, and are wash fast. The harder resins give stiffness and sheerness to a fabric, while the softer ones give body and fullness with a mellow hand. Their use aids in the production of finer, stronger textile materials with brighter, clearer colors, and with finishes which will last as long as the fabrics are used.

Cast rods, sheets and tubes

The harder acrylic resins, which have relatively high softening points for thermoplastics, may be prepared by casting. The monomeric esters are polymerized without solvent to give colorless transparent plastics. The most important acrylic plastic available in this form is polymethyl methacrylate.

This polymer is supplied in the form of rods of various diameters in lengths up to 48 inches. Rods can be machined, and hence find use in the manufacture of novelties, models, and displays. The extraordinary light transmission, between 90 and 92 percent, permits light to be "piped" through this material. By employing internal reflection, light can be conducted through a polished curved rod to emerge only where a frosted or curved surface is encountered. This property enables this acrylic polymer to be used in advertising signs and displays, for indirect lighting, and in scientific instruments.

Transparent sheets, either crystal-clear or colored, are cast in thicknesses from 0.60 to 2 inches. In certain thicknesses, sheets as large as 45 in. by 64 in., larger than any other transparent plastic sheets, have been manufactured. The high impact strength, low specific gravity, aging resistance, and ease of forming of cast acrylic sheets have promoted their use as windows and windshields in all types of motor vehicles. The aircraft industry has found these sheets particularly well adapted to its requirements, and therefore employs them in landing light covers, gun turrets, and cockpit enclosures, in addition to the windshield and window applications.

The optical properties of the acrylic resins make them suitable for use in spectacle lenses, camera lenses, magnifying glasses, and protective goggles. Spectacle lenses which require no polishing or grinding after removal from the dies are being molded to prescription from acrylic sheets. As with cast rods, light is readily conducted through cast sheets, and thus hidden light sources may be used in edge illuminating signs, displays, decorative carved screens, and instrument dials.

Tubes of various wall thicknesses, diameters, and lengths are available. These are used to observe the flow of liquids which do not attack the plastic, particularly where there is danger of breakage. Tubes are used in models, displays, novelties, and scientific equipment.

Molding powders

Acrylic plastics are supplied to the molding industry for use as both compression and injection thermoplastic molding materials. In this field where freedom of shrinkage after molding, and permanence of properties of molded pieces are of prime importance, the ability to prepare molding powders of various softening points without the use of plasticizers is a great advantage.

Since a compression molded thermoplastic with a high softening point is desirable, the lower polymeric methacrylate esters are the acrylic plastics most widely used as compression molding materials. As the basic resin is crystal-clear, it is possible, by the addition of pigments and dyes to produce any shade or color and any degree of opacity. Thus it is possible to prepare acrylic molding materials in a more complete range of colors than any other plastic.

The softening points of acrylic molding materials are high (160–195 deg. F., A.S.T.M., D-48-37). The molding temperatures range from 300 to 360 deg. F., and the pressure normally required is about 3000 lbs. per sq. inch.

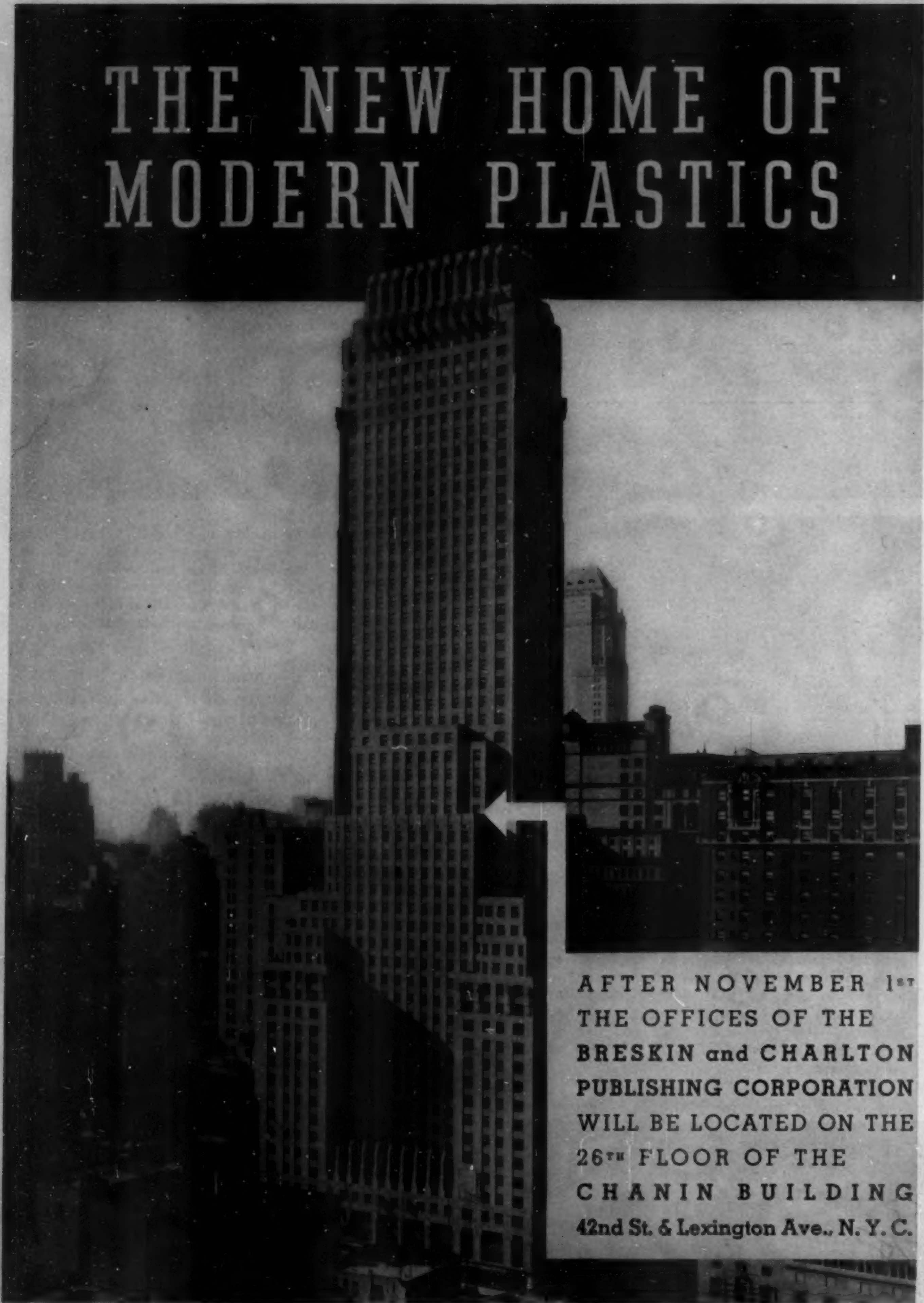
Compression molded acrylic plastics show excellent physical and electrical properties, low water absorption, good resistance to many chemicals and weathering. The avoidance of volatile solvents and plasticizers assures freedom from excessive shrinkage and turning brittle on aging.

Most injection molding materials contain high percentages of plasticizer to give them sufficient flow at normal molding temperatures. Quite recently an unplasticized acrylic injection molding material has been made commercially available. It is expected that the elimination of plasticizer from the injection material will permit the injection molding of pieces which have more permanent dimensions and properties than were heretofore possible.

Molded sheets

Molded sheets are supplied in certain thicknesses with limited surface area. These sheets have the disadvantage that they cannot be softened by heating previous to bending or forming, since the sheets have a tendency to unmold at elevated temperatures. Since the surface of molded sheets depends largely on the surface of the mold, it is necessary to have very highly polished molds in order to obtain sheets with smooth surfaces. They are useful where small plane sheets can be used and where optical requirements are not too high.

The excellent properties of the acrylic resins which make them outstanding among thermoplastics will doubtless open up fields where thermoplastics have not previously been used. Since many variations in the chemical constitution of acrylic polymers are possible, it is quite likely that products of even more widely differing properties and possibilities will be developed in the near future.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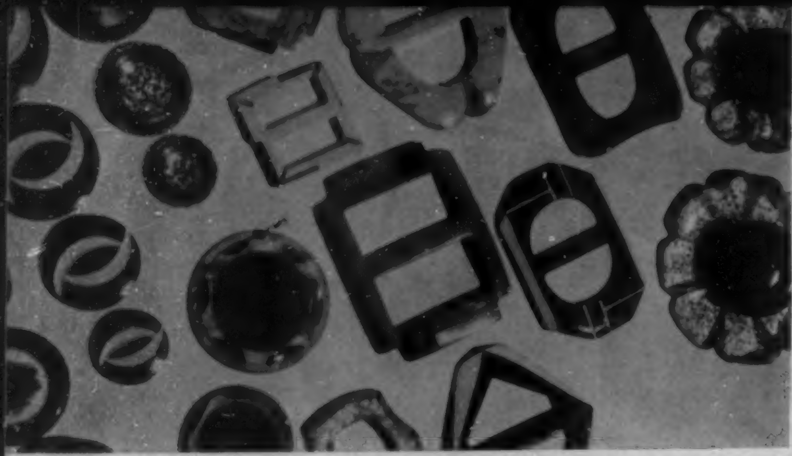


Buttons and buckles are stamped from sheet stock or cut from rods, have brilliant color and luster. These are from Voges Manufacturing Co.

CASEIN PLASTICS

(*Continued from page 17*) itself produced catalytically from materials abundantly available. It has the distinction of being one of the most versatile of the plastic raw materials, as it is needed not only for the formolation of casein plastics but in combination with phenols or with urea or thiourea it produces the important plastics of those classes.

Casein formaldehyde plastic is completely non-inflammable. It can be molded, turned, shaped, drilled and sawn. It takes a brilliant polish, which exhibits the colors of the material to great advantage, and it is cheap. It is used chiefly in the manufacture of buttons, brushes, combs, mirrors, knitting pins, low tension electrical gear, such as switch dollies, lamp plugs and dashboard fittings, fountain pens, propelling pencils and articles of ornament, such as beads, bag frames and umbrella handles. It absorbs water when continuously exposed to it, and is attacked by acids and alkalies.

The general trend of the casein plastics industry at the present time is an increased use for ornamental purposes, due chiefly to improvements in color and transparency, and also to mechanical improvements in methods of producing configurations, particularly in imitation of natural horn, which casein has very largely replaced.

The position of the casein industry in this country in a time of national emergency, such as war, is difficult to forecast. It must be noted that in many instances casein plastic is used for small articles formerly made from metals. This is particularly noticeable in the button trade. It is impossible to tell beforehand whether or not it would still be in the national interest that casein should be used for such purposes. If we had a home casein industry, and, in time of emergency there were any question of an acute shortage of food, it is probable that casein could not be spared for the plastics industry; but if casein plastic is required for national purposes and imported casein is available, it would be necessary to spare the shipping capacity to bring the casein into the country. Both in England and in France the casein plastics industry was carried on during the war of 1914–18, the British industry being forced to use imported casein. It is to be hoped that in similar circumstances in the future the home casein industry, in conjunction with Empire producers, would meet the emergency. The main purpose of this part of the paper is not to forecast what would or would not be necessary but to put all the facts on record, so that if casein plastics are necessary in times of emergency the raw materials may be forthcoming.

. . . .

Editor's note. This paper by Mr. Birrell describes the manufacture of casein and indicates the importance of the casein industry so clearly that we are happy indeed to be able to present it to our readers through the courtesy of The Institute of the Plastics Industry in England.

Production of casein in the United States is increasing yearly and the most recent available figures indicate the following volume:

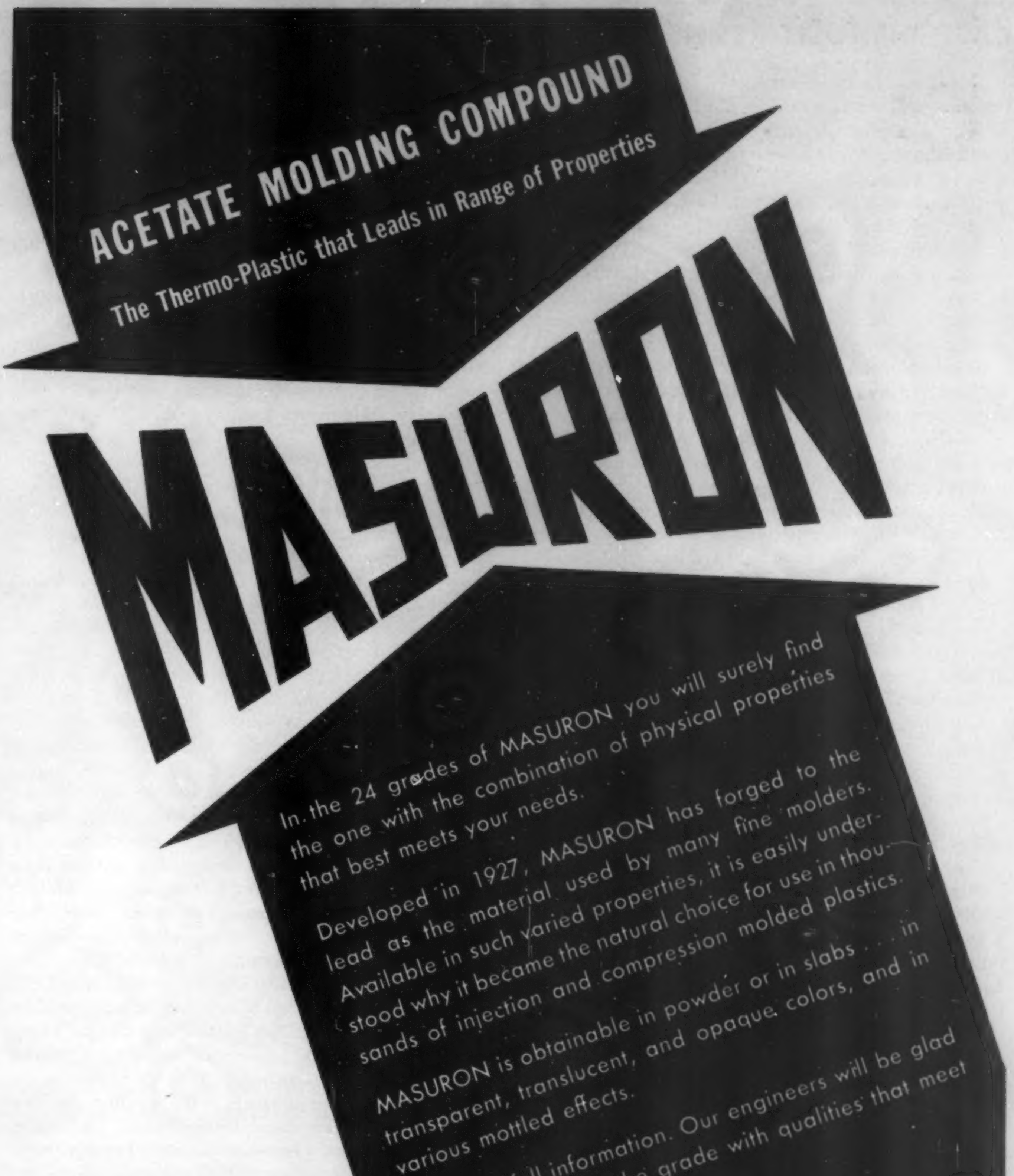
	1935	1933	1931	1929
Casein, dry:				
Pounds	43,276,254	30,119,739		
Value	$4,042,255	$2,492,742		
			41,375,639	57,826,167
Casein, wet:			$2,265,802	$5,725,571
Pounds	5,700,715	1,403,894		
Value	$231,057	$66,623		

Besides the applications mentioned by Mr. Birrell, there is a vast quantity of casein used in this country in the manufacture of cold water paints and cement. Casein cement enters into other branches of the plastics industry by providing a successful bond between laminated phenolic and urea sheets and the plywood backing to which they are attached for architectural and building purposes.

A recent invention, described in the August issue of this journal, is reported to shorten the manufacturing process for making casein plastics and offers economies which, when the process is once organized and in operation, should make this material available at prices which will open entirely new markets for its consumption. This process takes advantage of the natural milk sugar present in the casein rennet to avoid the formalizing operation. By introducing certain acids in the original mixing operation, the material becomes self-hardening and can be ground after drying into a molding compound.

Exciting predictions for the future of casein frequently pop up and because it is one of the lower priced plastic materials, exhaustive research is constantly going on. A newspaper release (*N. Y. World Telegram*, August 8, 1938) reported that we may soon wear suits of milk wool. It said: "According to predictions of the American Chemical Society, it will not be long before people will be wearing suits made of milk wool, held in place by buttons of milk, also sleeping under blankets made of milk. The prediction concerns uses of casein, the protein content of milk."

We are all acquainted with these buttons of milk, although we may not recognize them as such, but so long as there are plenty of sheep running around in our pastures, many of us are old-fashioned enough to prefer to have our suits and blankets spun and woven from the luxurious virgin wool with which they are blessed and which they have graciously contributed to the comfort of mankind these many years, even before plastics began. Nevertheless we may go from the sheep to the cow before we are done.


ACETATE MOLDING COMPOUND
The Thermo-Plastic that Leads in Range of Properties
MASURON
In the 24 grades of MASURON you will surely find the one with the combination of physical properties that best meets your needs.
Developed in 1927, MASURON has forged to the lead as the material used by many fine molders. Available in such varied properties, it is easily understood why it became the natural choice for use in thousands of injection and compression molded plastics.
MASURON is obtainable in powder or in slabs . . . in transparent, translucent, and opaque colors, and in various mottled effects.
Write for full information. Our engineers will be glad to help you select the grade with qualities that meet your every requirement.
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MASURON DIVISION
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BROOKLYN, N. Y.

CAST PHENOLIC RESINS

(*Continued from page 20*) properties which make its choice desirable, and more often than not he succeeds.

When cast phenolic resins graduated from the research laboratory some years ago, ready for production, there was but one basic formula. From this was made a material that at first seemed to have unlimited possibilities. It could be easily cast into simple open molds such as rods, sheets and tubes, and these could be sawed, drilled and machined into a seemingly endless variety of shapes. It was when customers tried to adapt the material to different uses that it was found to have very definite limitations as well.

As natural limitations of the material were discovered by users, laboratory chemists shut themselves in with their test tubes, retorts, burners and an imposing array of bottles, and set about analyzing, modifying, experimenting and testing various formulations to develop required properties. Among other things, customers needed good machinability, resistance to shock and high tensile strength, resistance to water and alcohol, and stability of dyestuffs to light and heat conditions.

Now it is difficult to incorporate into any one material, physical or chemical properties broad enough in scope to satisfy all phases of industry and cast phenolics are no exception. Consequently, in order to get any one of these characteristics, there must be more or less of a compromise. If high transparency and clarity in a resin is called for, tensile strength and machinability must be sacrificed to some degree. If the foremost requisite is excellent machinability, then transparency is sacrificed somewhat. Fortunately, traits absolutely indispensable to one application might not be as important to another, and by modifying the resin base, the customer's specifications can often be accurately covered.

Working out a resin that has all the qualifications for a specific job isn't done overnight, nor in a week nor even a month. Sometimes it takes years. For example, a brush manufacturer, whether he produces bath brushes, hair brushes or brushes for any other personal or household use, must have a material for the back of his product that is highly moisture resistant, for if it is not, sooner or later the bristles will loosen and fall out and nobody wants a brush that sheds bristles. Many different materials, both natural and synthetic, have been used more or less successfully for brush backs, but none have been proved to be 100 percent efficient. Since this is a sizable market, and since cast phenolics possessed many desirable properties for this application, it merely remained for the research chemists to devise a suitable formula which retained the original good characteristics, plus the added features required to make it an ideal material.

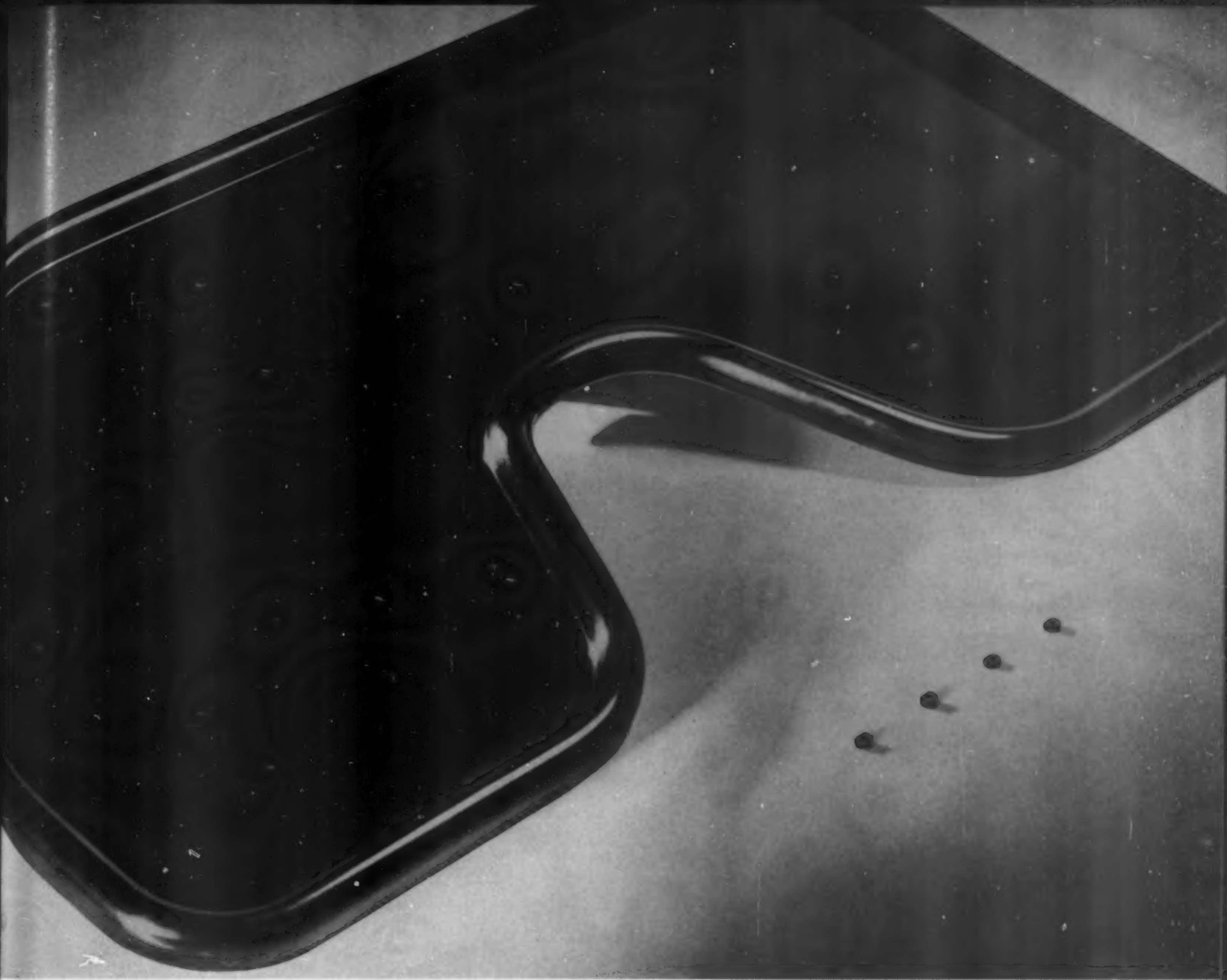
Their task wasn't exactly an easy one. Standard cast phenolic was strong enough to stand the drilling operations, but not sufficiently elastic to accommodate both the plunger and tufts of bristles. Nor was it soft enough at the base of the hole to accept the little wire prong staples used to anchor the bristles. The appropriate softness or plasticity could be secured by heating the material but the brush manufacturer could hardly introduce this operation without increasing his costs or changing his process. Naturally, he could not afford to throw out expensive automatic machinery just to accommodate a new material, however desirable that might seem to be. Therefore, the same degree of plasticity had to be embodied in the base resin so the manufacturer could put the material cold through his regular process.

The chemists started out with the known limitations in the basic resin—what it didn't do satisfactorily. With their experience and knowledge, they knew that eventually, by changing the ratio of one chemical to another or perhaps of several to each other, they could produce a happy, compatible family of molecules favorably disposed toward the brush proposition.

For three years they labored on one chemical structure after another. During that time an average of about 12 formulas a month were worked out—36 a year, or approximately 108 in all. Each in turn had to be cooked, cured and tested. Each had to pay a visit to the color laboratory, for the resin would be of little value unless it was susceptible to fast coloring. The best of the formulas were awarded with a production run and if the resulting material still looked good, it was sent along for further tests to several brush manufacturers, working under different conditions. The result, after three years of probing and prying into chemical intricacies, is an ideal material for brush back manufacture.

So it goes—the chemist's work is never done. No sooner is a resin perfected to take care of one type of application than along comes another that requires a little different treatment. Laboratory technicians, within the last two years, have been called upon to provide cast phenolics which far surpass in range of utility the forms in which they were originally produced. The various shapes of rods and tubes were followed by many really

Resin is carefully tested for the critical gel point (left) for if it remains too long in the kettle, polymerization is likely to begin. When tests reveal that it is ready to "kick over," the fully processed resin is drawn off (right) preparatory to pouring into lead molds for casting. (Photos courtesy Catalin)



"Sisters UNDER THE SKIN"

It would be nice for us and for our mold shop if all jobs that came in were the same size. But they aren't, so years ago we equipped our shop to meet all kinds of requirements.

We show here two parts that happened to be going through our shop at the same time recently. We don't claim that these are the biggest or smallest parts ever molded—but there is one significant point about them—the 24 in. wide tray is molded to the same precise standards of accuracy as the 3/16 in. bushing.

We've been molding parts for better than sixty years, and most of the time we've had to make our own experience. There just weren't any rules to follow in the early days, and so we made our own. It is one habit we've kept up—we still pioneer the tough ones and the only rules we follow are the job specifications.

Besides, we've found out how to keep costs pretty reasonable whether the job is special or routine. So, regardless of your next job, suppose you let us take a try at it. We've an idea you will be pleased with our results—lots of people have been.

Established 1876

MOLDED PLASTICS DIVISION OF

AUBURN BUTTON WORKS, Inc.

AUBURN, N. Y.—New York, Chicago, Detroit, Cleveland, Rochester, Boston

intricate castings which increased the demand for larger sizes and shapes such as radio cabinets and other type housings. To make such castings economical and practical, research chemists first had to develop competent liquid resins. Whereas there was originally only one basic formula, there are now nine, and each of these is subject to considerable modification to meet with diversified requirements.

When it comes to color, plastics have the advantage over contemporary materials because they are colored all the way through. Since in their liquid stage, cast phenolics are transparent and sufficiently clear to take dyes well, they have a depth of color and translucence to be found in no other plastic. Because the color is not applied, it cannot chip or wear off. No matter how much machining is done on the surface, the cloudiness or dullness caused by this abrasion is quickly and easily removed with a buff, and the original richness of tone and translucence restored.

Here again the research chemist is kept on his toes figuring out formulations for new colors and matching samples from customers. Because color trends, like everything else in these fast moving times, change with the seasons or even oftener, these must be ready in time to catch the market before it shifts. It used to require a month to produce a satisfactory new color. Now, a customer can submit a sample on Monday morning, receive the cast resin match by the end of the week, approve it and shoot it back, and it will be ready to go into immediate production.

This substantial saving in time is the result of years of intensive study and experimentation with dyestuffs and pigments. Actually there are but twenty-four dyes that are considered permanent enough for use in cast phenolics. This doesn't mean, of course, that only twenty-four colors are available. From these dyes many thousands of different shades and tones have been formulated and placed on file for convenient reference—from pale ivory through the spectrum to jet black. Each one of these is thoroughly tested for resistance to heat and light over a period of time, and when a color finally joins the others in the file, its characteristics are known to be sound and reliable.

When a customer submits a sample specimen, it is checked with the file to see if by chance it matches any of those already formulated. It it doesn't the chemist sets about making it. His first step is to break the color down into its component parts, which he does by means of a standard chart of color values. Once he knows what the color consists of, he proceeds to duplicate it in the cast phenolic. Suppose he is working on a red—there may be six reds in the twenty-four staple dyes. He knows that one of these, combined with another color is bound to give him the shade he wants. Perhaps he needs a little yellow, or blue or a happy combination of both, but there is no set rule as to the amount of each he should use. Not only must he get a perfect color match, but the formula must work out equally well in production, allowing for normal variations that may appear.

Research chemists in the cast phenolic resin industry probably have had more experience with liquid resins than chemists in any other type of plastic plant. They work with liquids and control them through every step of the process except the last one, which is polymerization. As a result of this experience, they have found that the same resins, with suitable modification, can be supplied in liquid form for laminating thin pieces of paper together into translucent sheets for industrial and decorative uses such as lamp shades, graphic charts for permanent records, advertising signs and displays, radio tuning dials, etc. This requires a clear resin that will penetrate evenly, cure quickly and make the paper lightfast, waterproof, non-shrinking, strong, durable and heat resistant. Early phenol-formaldehyde resins had a tendency to darken on exposure and while some of the other requisites were present, not all of them could be obtained in any one resin.

Through their intimate knowledge of cast phenolic resin structure, research chemists were able to formulate a clear laminating liquid that retains its transparency even after long periods of exposure. Material laminated with this liquid has exceptional tensile strength, light and moisture resistance, and is receptive to embossing, printing and blanking operations. In addition, color possibilities are almost unlimited.

Along with the research on laminating varnish, a resinous glue was developed for bonding plywood. Realizing that cast phenolic resin liquid has excellent adhesive qualities, laboratory chemists undertook to put it into usable form for wood veneering, and worked out a hot setting, moistureproof, verminproof, glue that has high tensile strength. Whether or not the surface of the wood is uniform, this glue, spread thinly, penetrates the cells of the wood, thus making a much better joint than that obtained by older or more conventional methods. It is not affected by variation of water content in the wood which means that it is easy and economical for the mill to handle.

Another transparent glue was developed simultaneously for joining plastics to each other or plastics to wood. With the popularity of transparent plastics growing every day, this glue or cement provides a bond that is entirely invisible when properly applied.

Besides all these research activities, the chemical laboratory devotes considerable attention to the control of material in production. From time to time, samples are taken from the kettles and tested for each of the properties they are supposed to possess. In this manner any variation between the original batch cooked up in the miniature laboratory kettle, and the batch in production, is quickly discovered and corrected.

And so we leave the chemist at his work, feeling quite certain that the materials which are so familiar to us now and which appear to be so satisfactory, will in time be supplemented and replaced by new varieties of cast phenolics of even greater adaptability and broader service. Present uses of these materials were never dreamed of ten years ago, and the new ideas and developments which are bottled up in the laboratory today will undoubtedly be the popular products in the markets ten years hence.

CELLULOSE NITRATE

(*Continued from page 22*) tion in 1891 of the wheel method of forming practically endless sheeting or film, a product of almost immeasurable value in the moving picture and photographic industries. It is significant to note that this process is the basis of the present-day method of making pyroxylin and safety film. Here was another tool developed for the pyroxylin plastic to be handed down to the coming generations.

Having made the plastic, the art of working it into finished and usuable products quickly followed. Probably no other material can be produced in such a wide range of decorative effects, nor with such versatile working qualities. By means of dyes and pigments which may be incorporated in the plastic mass in an endless variety of ways, a rather lifeless substance becomes extremely attractive to the eye, lending its character and beauty to ever broadening fields of utility.

This dressing up of the plastic base is accomplished by various methods depending upon the particular use for which the finished product is designed. For many purposes it is only necessary to add a bright transparent color as in the case of guide cards, eye shades, signal devices, etc. Other types of applications demand some degree of opacity with perhaps a distinctive decorative mottling or variegated effect as in buttons, knife handles, pipe bits, tooth brushes, toilet articles, toys and novelties. A more extensive field of application is one in which different basic colors, dyes, pigments or lustrous agents are so utilized as to produce imitations of the most beautiful products of nature such as ivory, horn, tortoise shell, mother of pearl, onyx, quartz, marble, lapis lazule, semi-precious stones, rare woods, etc., which oftentimes in their natural state are not easily adapted for machining or fabrication into the countless articles with which we are familiar. The delicate mottling, gradual shading, scintillating luster, depth and richness of color, translucency, vivid and pastel tones are difficult to describe in words, as also the many other patterns often referred to in the trade as corrugations, continuous and broken striations, drift formations, herring bones, checks, moirés, plaids, stripes, mosaics, etc. Kneading, filtering, rolling, pressing, sheeting, restacking and resheeting, etc., are all processing steps fortunately accessible to the colorist for the manifestation of his artistic skill and ingenuity.

The means of fabricating this unusual material are also multiple, giving the artisan a broad choice of tools and methods. As the material is thermoplastic many articles are molded to final shape in heated molds under pressure with subsequent chilling to set the material. In the manufacture of hollow articles fluid pressure is applied internally and the material blown or expanded to the shape of the retaining mold. Other articles are more economically fashioned by mechanical operations such as blanking, sawing, milling, routing, drilling, tapping, turning and such operations which may be applied to wood, soft metals or similar materials. The pyroxylin plastic may be heated and stretched within the elastic limit of the material, and then set by cooling so as to retain stresses in the material which, when released by reheating, tend to restore the material to its original form. This principle is utilized in the veneering of such articles as golf shafts, towel bars, strap hangers, etc. Certain solvents have the property of softening pyroxylin plastic without dissolving it so as to render it tough and very pliable. Plastic sheets so softened and stretched over wooden forms such as wood heels, toilet seat covers, hamper tops, etc., shrink tightly over the form in a strong and durable veneer.

The pyroxylin plastic is readily cemented to itself by the use of suitable solvents, and to many other materials by means of body cements. This property is of great advantage in simplifying the fabrication and assembly of many articles.

As a further decorative feature the beauty of the material may be enhanced by a highly polished surface produced mechanically by buffing wheels and suitable abrasives, or the surface may be printed, embossed by heated dies or engraved.

These are the tools and methods, the lessons and experiences which the pyroxylin plastic hands down to the benefit of the newer and younger plastics. In advancing years it is gradually retiring from some of its fields of activity, but it still retains much of its former vigor and vitality in other fields. Its beauty and character have not faded with age. The pyroxylin plastic is still strong, tough and able to absorb an unusual amount of punishment as witnessed by its continued use in tool handles of all kinds, mallet heads, golf club facings, shoe heel covers, shoe lace tipping, tooth brush handles, etc.

Its extraordinary working qualities are unapproached by other materials, except in cellulose acetate, the kindred product which is gradually taking its place because of recent technical advances, and lowered cost of production. The newer plastic is also non-inflammable. Both products permit unusual coloring and complicated color configurations acquired only through many manipulative steps in processing not yet practical in other materials. This quality of easy workability also renders possible many blown novelties and toys which delight children. Although pyroxylin plastic finds application in high places, it also has its appeal in fields where price is a consideration, such as for printed blotter covers, novelties, campaign buttons and such.

Truly, the pyroxylin plastic has played a noble pioneering part in the plastics industry. It has paved the way for the advances of chemical science in the plastics field by supplying much of the mechanical and operative means of manufacture and fabrication as well as the very market itself.

Pen and pencil set of Celluloid by David Kahn, Inc.

DESIGN FOR MOLDING

(*Continued from page 27*)

Perhaps the most spectacular progress has been made in the field of injection molding, where automatic machinery and newly developed materials have resulted in flexibility, speed of production, and capacity unsuspected a few years back. Nor is injection molding limited to small pieces, as is the popular conception. Large radio escutcheons, automobile steering wheels, spotlights, and garnish moldings having as much as 260 square inches of surface area, have already been molded on these larger machines, and this process is still in the earliest stages of its development. The essential differences between the injection and the conventional compression method of molding have already been brought home to us as designers. One of these differences is in the treatment of surfaces. In a conventionally molded piece, especially if the material used is other than a thermoplastic, it is often desirable to break up a large surface, as we have earlier mentioned. In injected pieces, where variegated materials are used, the opposite practice is sometimes used, that is, to leave the surface clean and unbroken so that the texture and the pattern interest of the material can be shown to full advantage.

It can almost be taken as an axiom that the more beautiful a material, the more expensive it is, and thermoplastics are no exception. However, by using a die casting, stamping, or other material as a core for a thin layer of plastic, beautiful effects can be gained at relatively low cost. The process of supplanting gold, copper, or chrome plating by thermoplastics has also met with wide favor in such applications as automobile and architectural hardware. Thermoplastics can be molded around any material sufficiently strong to stand the pressure of the molding operation. Many interesting developments have taken place utilizing this principle, where (formerly) solid plastic pieces could not be considered because of breakage. Glass bezels integral with thermoplastic frames have found wide application in the radio and refrigerator industries, and the future of this method in the design of clocks, automobile instrument panels, and transparent display packaging is limitless.

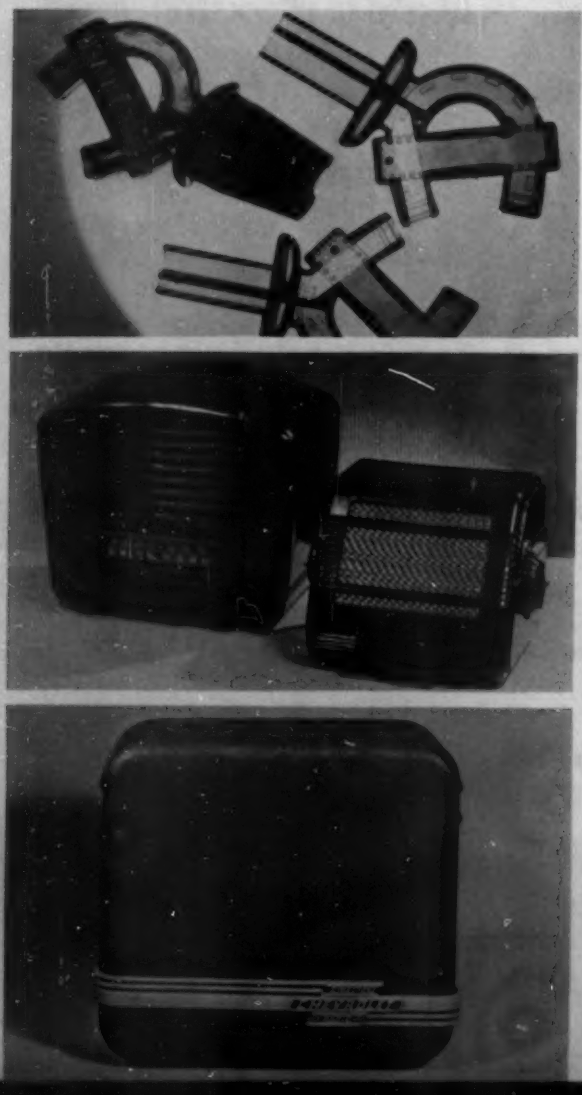
The facility with which two different pieces of thermoplastic materials can be cemented together by the use of acetone or other solvents offers the designer many opportunities for interesting treatment. Undercuts and complicated interior shapes can be obtained by molding the piece in two halves and cementing them together, as was done in the plastic liquor pourers illustrated. To make this in one piece would necessitate pulling cores from so many directions as to make it practically a molding impossibility.

The cementing process is valuable in still another way. A piece is often desired whose material content exceeds the capacity of the machine available. The product can be broken up in two or more pieces, and so designed that the joints are entirely suppressed by a line, bead, or step treatment, which forms an integral part of the design.

The injection process allows the designer more freedom, inasmuch as slides and split molds are less expensive than in conventional molding. His designs are not limited to simple straight draws, with all lines running parallel to them. Animals, costume jewelry, novelties and tokens can be cheaply produced in large quantities with all the modeling and undercutting necessary.

As thin wall sections are feasible, many decorative applications have been made where formerly plated metal and stamping were the materials considered. These applications have been attended usually by lower production costs. The ornament illustrated, which is for the Chevrolet radio case, is a good example of the substantial saving made by elimination of expensive plating and polishing operations necessary with the customary metal ornament. A further saving was made on this ornament by utilizing the gates by which the material flowed into the mold as studs to assemble the piece onto the case. Speed nuts were used for this purpose.

All these practical considerations emphasize the fact that the designer, to fully exploit the possibilities of plastics, must have an engineering, background. The competent designer complements this background with the imagination necessary to arouse, by visual means, desire on the part of the consumer for the product.



Undercuts and complicated interior shapes by injection molding are well illustrated in the Green River liquor pourer shown apart and assembled above. Two Crosley radios of recent design appear in the center. The metal housing for the Chevrolet radio (below) has an ornamental urea nameplate which saved costly plating and polishing operations. (Photos courtesy Sundberg and Ferar)

Liquid resinoid being poured into lead molds which give it the approximate shape of its finished form

These are pipe stems being removed from the lead molds after days of hardening at controlled temperature

A few touches on a buffing wheel complete a pipe stem superior to amber (Photos courtesy Bakelite)

FABRICATING CAST PHENOLICS

(*Continued from page 29*) bearing hangers and short constant tension drives give excellent results. A blower system is essential and usually every machine is equipped with an adjustable connection that will facilitate removal of dust, fumes and shavings.

Castings in special shapes that are not to be turned are cut into blanks of correct thickness by means of cut-off machines having thin abrasive wheels which travel at high speed. Each machine must be equipped with a fresh water connection, as a constant flow of clean water is absolutely necessary. A heating unit on the water feed line raises the temperature of the water during the winter months, and prevents the operators' hands from becoming cramped. Each machine must also be piped to remove the water, which is never used over again, and blower connections are also installed to eliminate fumes. Wheels are relatively inexpensive, and with proper care require infrequent changing. They are sharpened by cutting brass pipe or copper tubing with the water supply shut off.

The button industry particularly, uses slicing machines that cut button blanks from rods or buckle castings with no waste. Rods are heated by immersion, and the operation is almost entirely automatic. If, however, close tolerances are required, better results can be obtained by means of abrasive wheels.

Very large parts and samples can be readily cut on a band saw. Saws should be of the metal cutting hard edge type, and number of teeth per inch and set determine smoothness of cut. Automatic saw sharpening equipment has proved its worth, as saws that have been resharpened give better results than when new, and saw cost is reduced as much as 90 percent. If parts are sawed, they must be surfaced on a belt or disc sanding machine before being finished. Sanding belts, traveling at fairly high speed, give very good results. If finished surface is to be flat, conventional type of machines are used, but belts traveling over two pulleys and unsupported in the center are found of great advantage when removing small projections on rounded surfaces or performing other operations when a flat surface is not desired.

Pen bases and similar articles are beveled on beveling machines or shapers, having ball bearing spindles. Bronze alloy, brass and steel cutters are used. Cutters should be sharpened only by one skilled in this type of work, and absence of vibration is also important. If tools are improperly sharpened or spindle is not true, the work may chip.

Irregular shapes, samples and small quantities of production parts can be easily jig-sawed. Saws are usually made by the jig-saw operator, as he is thus able to select the number of teeth and set required for a smooth surface. Outline of parts to be sawed may be scratched on the surface of the sheet or a printed pattern pasted to the surface with water soluble glue. If a number of parts are to be cut, several sheets are pinned together. Oiled paper inserted between the sheets lubricates the saw and helps to obtain a smoother surface. Many letters and

Castings of this sort are accomplished with phenolic resins, either in lead or rubber molds. Radio cabinets and other small cast housings are increasing in popularity because of the transparency cast resins afford. This statuette of Venus was cast of Crystle in a rubber mold by The Marblette Corporation

signs are made in this manner, and all that is necessary is an inexpensive paper pattern. Very good results are obtained by using cast-in-glass sheets, which have a glass smooth surface, and the letters thus require no polishing after they are sawed.

Small parts may also be blanked from sheets, and this method is often employed by the jewelry trade, as a supply of sheets in various colors and thicknesses may be kept on hand and immediate delivery made to the customer, regardless of style changes. However, it is much more economical to fabricate parts of this type from castings, having outline shape of finished article, as there is a minimum amount of waste.

Jewelry parts and similar articles can be readily carved. A ball bearing spindle is generally used with either small steel, bronze or brass cutters or shaped abrasive wheels. Skillful operators can carve hundreds of pieces with almost no variation in design. Each machine is equipped with a number of shaped wheels, and wheels may be quickly and easily changed. Original designs are quite often worked out by the operator as expensive tools, dies or patterns are not necessary.

Turned parts, having center holes, are drilled while being turned, while castings and odd shaped parts are easily drilled with the usual type of high speed vertical drill, having its own motor or driven from a line shaft.

Cast resins can be easily tapped on vertical or horizontal tapping machines. Standard taps are used, and greater strength is obtained by using fairly coarse threads. Tapped holes should be checked with plug gages, as the abrasive action of the material causes wear. Drive screws and self-tapping screws eliminate the necessity of tapping, and are extensively used for attaching jewelry findings and other small metal parts.

Although milling cutters can be used when slotted sections are necessary, better results are obtained with special machines equipped with grinding wheels of correct grit and hardness. A constant flow of fresh water on the wheel and the work eliminates "burning" and dust, and helps to provide a smooth surface. Wheels have a much longer life if sufficient water is used.

If parts must be formed, electric steam tables slightly soften the material so that it may be bent to correct shape. Parts may also be softened by immersion in hot water or by dry heat.

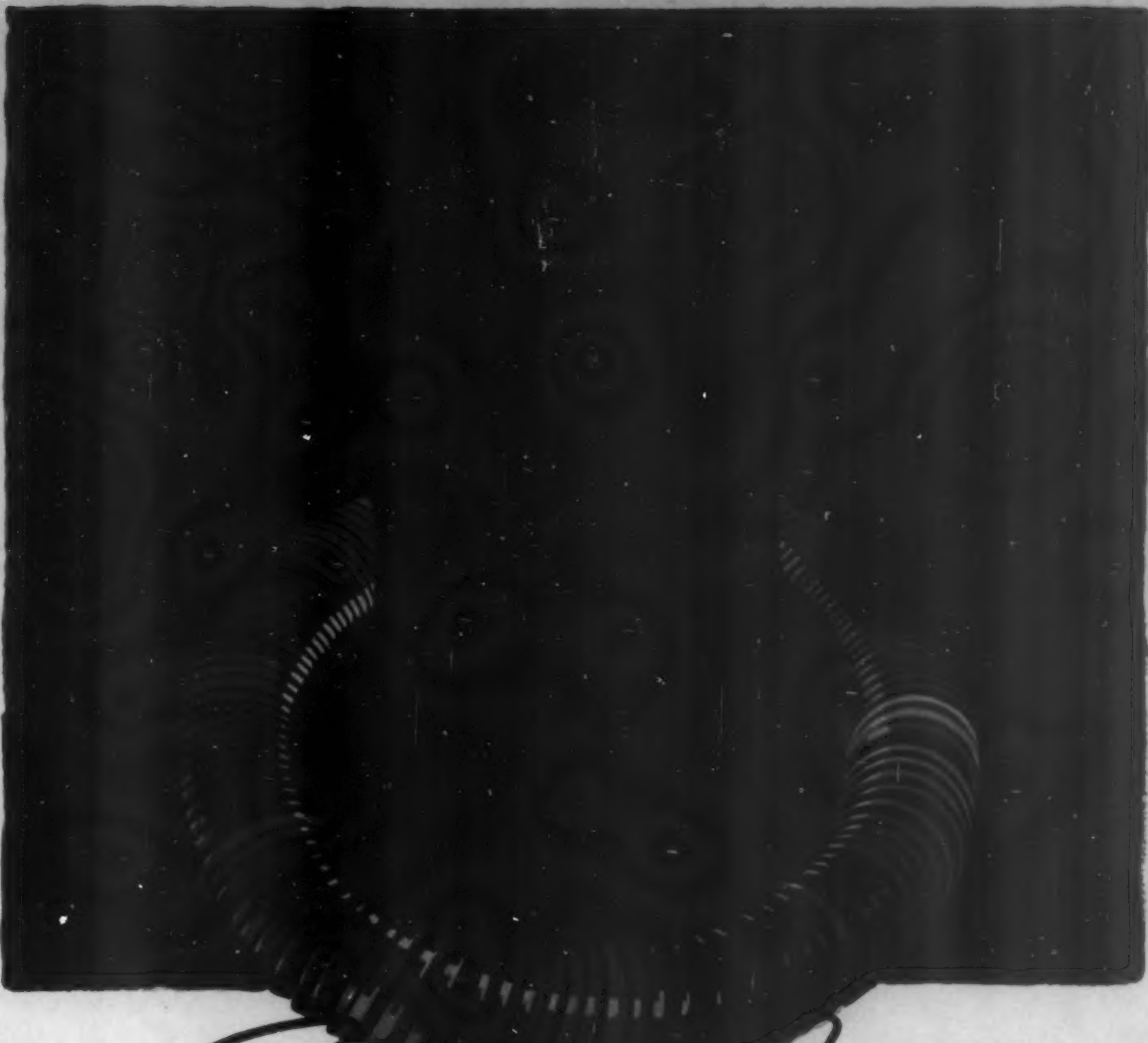
When all machining operations have been completed, articles are ready for finishing. Small parts and those not requiring a high luster can be tumbled in wood or wood and steel barrels. There are several concerns that manufacture these barrels and supply formulas for finishing cast resins.

Larger parts and those on which sharp corners and edges must be retained should be hand finished throughout. There are several methods, one of the most common being an ashing process, followed by finishing on a cotton buff. A thick mixture of fine pumice and water is applied to the wheel with a wooden paddle, and when the work is held against the wheel, all tool marks and sand marks are removed. Another method, used principally in the pyroxylin fabricating sections of the country, consists of a wheel composed of carpet disks traveling in a solution of water and sifted anthracite ashes.

The final finish and high gloss that brings out the beauty of the material is secured by polishing on a cotton buff. One section of the wheel's face is not coated with polishing compound, and when parts have been buffed, they are wiped on this dry section. Air cooled wheels have been developed that enable the operator to highly finish the article without danger of friction "burning." After parts are polished, they are placed in racks or boxes and carefully handled to avoid scratching. They are now ready to be inspected, counted and shipped.

Cast resins have entered the radio field and manufacturers of radios claim improved tone, increased sales appeal and greater strength. Designs may be simple, as the beauty of the material alone commands instant attention. Transparent and opaque bowling balls are rapidly winning favor with expert bowlers. In addition to their beauty, it is said that the greater "liveliness" of the material enables the bowler to obtain higher scores. Bowling balls are cast in glass molds. The glass is destroyed when the ball has been cured, and the fabricator removes the neck, turns them to accurate dimensions and finishes them by hand. They are sold at a price that compares favorably with competitive materials.

Streamlined housings have been made for office appliances and similar articles. They lend a new touch of beauty and design to otherwise drab equipment. Parts are made for huge trucks and toy electric trains, chromium and copper gift articles, lamps and modern furniture. Producers of raw material, manufacturers and fabricators look forward with optimism to a period of development that will far exceed that which has occurred during the past decade.



FILLER REQUIREMENTS

(*Continued from page 31*) mentioned later in this paper.

There seems to be no analogy between the strengthening action of certain very fine fillers in rubber and their effects in thermosetting resins. In fact, the rubber type fillers exert little or no strengthening effects in resins, being thereby distinctly inferior in this respect to the fibrous fillers. This distinction between the rubber and thermosetting resin fillers apparently has not been appreciated and has been the reason for submission of many unsatisfactory fillers for thermosetting resins.

Low moisture absorption of the filler is generally unappreciated as an important property. The moisture absorption of the pure resin, particularly phenolic resins, after complete polymerization is extremely small. The major proportion of absorption of a molded piece may, therefore, be attributed principally to the filler. But why is moisture absorption of importance? The answer is simple and direct. The molded piece is almost continuously in contact with moisture in the air while in service. If its resistance is poor and particularly if the humidity is high, defects will show up in surface gloss, dimensional changes and lowered electrical properties. In abnormal cases of high humidity and temperature, poorly molded pieces have been known to disintegrate.

In discussing the term "molded gravity," *low molded gravity* means the specific gravity of the piece made from the compounded mixture of resin and filler. This "molded gravity" is only indirectly proportional to the gravity of the filler in its natural state. For instance, most woods have a specific gravity in their natural state of under 1.0. However, their molded gravity is of the order of 1.4.

The importance of specific gravity is thoroughly appreciated by the molders but not so well by potential raw material suppliers. Again the explanation is simple. The molder purchases his compound from the plastics manufacturer at a certain price per pound but in turn sells at so much per piece. In other words, he buys on a weight basis and sells on a volume basis. The relation between these two is specific gravity. Even if plastics manufacturers should change their price basis and sell on a molded gravity basis, which is unlikely, the fillers of high gravity would still be at a disadvantage because of processing costs.

That the filler must be *easily wetted* by resins and dyes is perhaps self-evident. It is necessary to good bonding and to good finish of the molded piece. Having stated this obvious fact, it is, however, very difficult or impossible to give the factors which influence it. Actual experimental testing by the plastics manufacturer in his particular process and equipment is always necessary to determine this factor. Fortunately, the phenolic and urea resins at the compounding stage have a much superior ability to wet most fillers as compared for instance with many of the thermoplastics.

The possible ill effects of fillers on the steel dies used in molding is another factor very little appreciated. Fillers may contain *abrasive* particles as impurities or, in

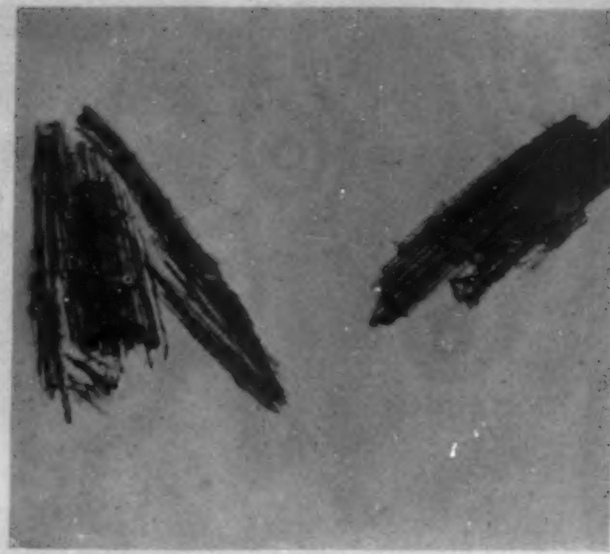


Fig. 5.—Attrition mill grinding of hemp hurds X175

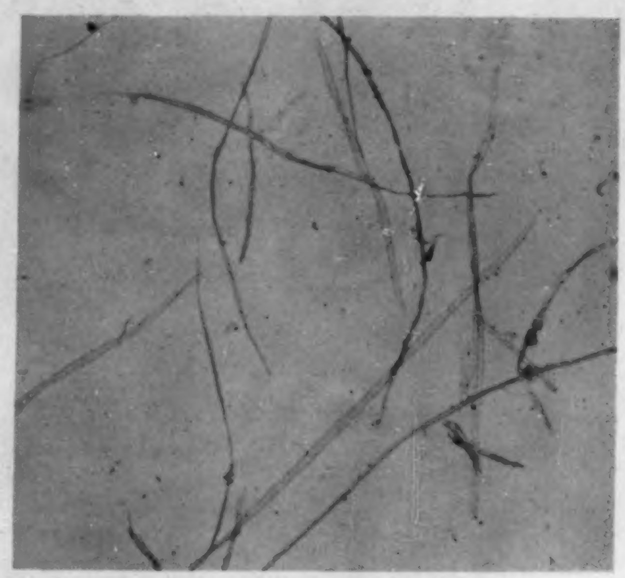


Fig. 6.—Impact filler before compounding X35

some cases, the filler itself may be abrasive. The removal of impurities is, of course, a matter of proper manufacturing technique. However, the abrasiveness of the filler itself is usually a matter of practical test. In general a cellulose filler of high ash content should be examined closely. For mineral fillers the scratch hardness may be used as a rough guide.

The chemical effects of fillers on molds may be no less marked than the abrasive effects. Again, their detrimental effects are so closely related to the particular resin, process of compounding and molding conditions that it seems necessary to leave decision on this point to actual test. This is more likely to show up in cellulose fillers. In general, a wood of low resin content has a better chance to prove satisfactory.

Abrasiveness or chemical action due to the filler causes high mold wear and often results in serious molding production delays, both of which will reflect in higher costs to the ultimate user. Nevertheless, it should be understood that high mold wear is not always due to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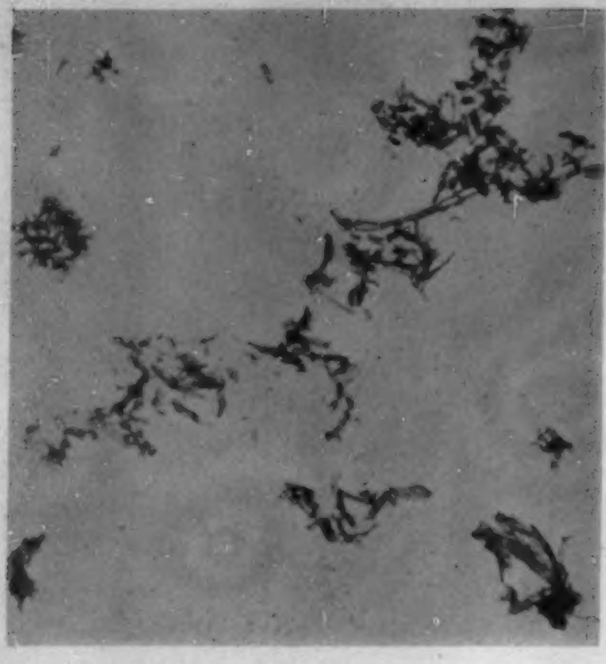

Fig. 7.—Impact filler after compounding ×35

these reasons. It can just as readily be caused by improper molding technique.

Low cost and large supply are again obvious requirements for volume production of plastic molding materials. It should be remembered that price alone will not sell a filler. It is a lower price plus equal properties or the same price with distinctly better properties.

The plastics industry has from its inception had excellent technical control and supervision. The fillers employed have accordingly been carefully selected and maintain their position by right of superior usefulness and lowest costs. Any supplanting of these fillers, while by no means impossible, will have to meet the severest tests and practical trials.

Secondary requirements

A considerable portion of molded parts has *electrical insulating* requirements as well as others. For wide use it is necessary that a filler be reasonably good in this respect—at least as good as woodflour.

Initial *color* as well as *color stability* under conditions of use are important not only in urea-formaldehyde resins but also in phenolics. As a matter of fact, with urea resins, this requirement should be placed with the primary factors, since colors, particularly light shades, are the main stock in trade of this resin. Even in phenolics where pastel tints are not attempted, any tendency to go off color will hamper use of a filler except for dark shades.

With the development of resins having better *chemical resistance*, particularly acid and alkali resistance, this also becomes a requirement for the filler. Solvent resistance is usually of importance as far as filler is concerned only in that the solvent must not leach any substantial amount of soluble material from the filler. This is particularly important if the leached material be colored. It will be revealed in the molded piece as *bleeding*.

Many molded pieces are *machined*, particularly drilled and tapped. Any undue wear of the cutting tools will be cause for rejection in many plants. This is often tied up with the same causes as high abrasive effects on molds, which have already been mentioned.

Heat resistance and *flammability* may be considered together. For these requirements, it is highly desirable that the filler does not support combustion. It should show no tendency to ignite at temperatures below those which the resins will withstand. Furthermore, when heat resistance is essential, the filler should not be subject to decomposition under continued elevated temperatures. Phenolic resins are now available which will withstand 450–500° F. for hundreds of hours. The filler should withstand this or preferably a higher range in order that overall heat resistance may not be sacrificed.

The requirement of availability in *controlled mesh size* and *bulk factor* needs some explanation. In general a filler will be used in a relatively finely ground condition. The fineness of this grinding will represent a compromise and must be capable of being held within certain limits. Furthermore, it is important the ground filler should not be excessively bulky or fluffy. This last is not only of some importance in handling but more in the danger that the molding powder will become so bulky that it cannot be handled in automatic machines and in the molds currently used today. The use of this automatic equipment and the design of these molds are so well established and offer such economies as to render any change extremely unlikely.

Many applications, such as closures, require a molded piece of minimum *odor*. It has been popularly supposed that odor is always derived from the resin. This is incorrect and care must be exercised that rejection on this score is not due to the filler. Volatile or soluble constituents of the filler are likely to be sources of trouble.

An analysis of present-day fillers

Having described some of the properties of the ideal filler, it is now in order to examine some of the more common present-day fillers to see wherein lies their usefulness and where improvements could be made. The first filler, because of its wide use, particularly in phenolics is woodflour.

Woodflour

As a general statement, woods which are low in solvent soluble constituents and light in color are potentially good fillers. This requirement is most easily met by the softer woods such as varieties of pine (ponderoso, sugar), Norway fir (abies balsamea), spruce, poplar, basswood and cotton wood. Certain hard woods have been used, among which are maple, oak, birch and gum. The color imparted by the wood to the molded piece is of considerable importance and since lighter shades are usually obtainable from soft woods, this is often a deciding factor. Care in selection of the wood to insure

minimum contamination such as knots, bark or other foreign material is also of importance in a filler selection.

In addition to the choice of wood, it is just as important that it be properly ground. This matter of grinding has been the subject of a large amount of investigation. It has already been stated that *fibrous* fillers give best strength in thermosetting resins. Efforts in this field have been in the direction of providing a fibrous woodflour of the right mesh. It is well known that the fibers in wood are aligned in a parallel direction along the axis of the tree, and that wood shows high directional strength along this same axis. The wood is ground in such a way as to give defibering rather than disintegration of the type expected of impact grinding. Such a method of grinding retains the maximum strength inherent in the wood fiber and yet gives a finely ground product. This may be classified as *attrition* grinding in contrast with breakdown by impact or cutting. Woodflour produced today will vary in particle size, but generally is ground so that maximum distribution is around 100 mesh but none coarser than 50 mesh.

The microphotographs show a variety of woods ground by different methods to pass the same mesh. Such photographs while showing differences in particle shape, size, extent of defibering, fail to indicate the particle size distribution or yield of usable material from any one type of machine. Suffice it to say that, in general, attrition type grinders show decided superiority.

This is illustrated in photographs 1 to 4, inclusive. The microphotographs, Figs. 1 to 5, inclusive, are all made from samples screened through 80 and on 100 mesh. Fig. 1 is a typical attrition ground woodflour. The reasonably good defibering may be noted. Fig. 2 shows an impact ground flour. Less defibering is quite evident. Fig. 3 shows a particularly well-defibered flour produced by attrition grinding. Fig. 4 is a saw cut sample, with almost no defibering.

These photographs will also indicate that screening difficulties increase with defibering, and that mesh distribution may be deceiving, since the better the defibering the more difficult the separation by screening.

Many possible substitutes for woodflour have been offered. Some of these have been minerals and have failed due to low strength and high specific gravity. Others have been of a cellulose fibrous structure and have failed for various other reasons, often moisture resistance. An example of this type was hemp hurds. The hemp stalk consists of 15–25 percent fiber which goes into the various well-established uses. The remainder of the stalk is probably of a fibrous type but has none of the fiber length of the portion above, and also contains a diversity of other materials. This 75–85 percent is known as hemp hurds. When comparably ground, it has an appearance much like woodflour. A microphotograph of this filler is shown in Fig. 5. The examination of this photograph will indicate rather poor defibering. It is also likely that such a picture fails to indicate the heterogeneous nature of this filler, particularly the pithy portion.

On being used in a molding composition, and comparing them with woodflour, hurds show poor advantage in strength (tensile and impact), higher moisture absorption, higher shrinkage and poorer surface appearance. The poor surface appearance was due to specks of filler and to higher moisture absorption. The specky condition could probably have been removed by finer grinding, but this in turn would likely result in still poorer strength properties. Many other examples could be cited to show similar comparisons.

Since the use of other fillers arises from deficiencies in woodflour, this part of the discussion may be passed over briefly to be taken up as these other fillers are discussed. Their use centers chiefly about impact strength, moisture and heat resistance, electrical properties and color. While the other properties of wood may not be the maximum obtainable, its low cost, availability and generally good properties make it eminently satisfactory.

Cotton filler

Cotton filler ground to a relatively fine mesh is known as flock and is used to a considerable extent in place of woodflour. Being almost pure cellulose, it combines excellent strength properties with low moisture absorption. Notwithstanding these excellent properties, cotton, as a filler, has some serious difficulties. The cost is high, being at best several times that of woodflour. It also gives a bulky, fluffy product which is difficult to handle in automatic processes. Nevertheless, there is no doubt that considerably larger amounts of cotton flock would be used if the price were considered in line.

Cotton linters are available in a price range below that of flock. It is much more bulky than flock and may, in addition, contain contamination picked up in handling or from the cotton plant or seed. These contaminants are likely to go through the compounding process and show up in mold scoring or as imperfections on the surface of the molded piece. The molded specific gravity of cotton filler is comparable with that of woodflour.

Alpha cellulose filler

This filler is superior for certain purposes due to its pure white color and easy wettability by resins and dyes. Included with these properties are reasonably good strength properties. It is used to a large extent in urea-formaldehyde resins where color and light shades are of greatest importance. No doubt the high price of this product is a deterrent to its wider use. Its moisture absorption is higher than that usually obtainable with woodflour or cotton. Woodflour has been used instead of alpha cellulose on an extensive scale in urea-formaldehyde production abroad. This can only be done for the darker shades of colors. It remains to be seen whether a field exists for such a substitution in this country.

Fabric types

These fillers find a place where greatly improved impact is necessary. Considering the fact that these must

be macerated in the compounding and molding, it was natural that waste products, trimmings, clippings, etc., should have been used from the start. There is also the element of cost, which is much lower if waste materials can be employed. While woven asbestos has been used to a slight extent, cotton base goods have been used in the greatest quantities. Here a bulky molding material is accepted as a necessary evil. Molds are designed accordingly and automatic preforming is not attempted. There are several varieties of molding materials from these fillers. The properties already given generally for fillers apply, but in addition it is often necessary to consider the type of weave, its closeness and the tight or loose nature of the twist. Until recently, these products have been relatively poor in molding properties and only moderately good in moisture resistance. Recently, however, new types have been introduced which are greatly improved in this respect.

More than the ordinary care is necessary in purchasing fabric fillers of this type. Being in general waste materials, contamination is more than likely to be present. The segregation and collection of these products to obtain a certain weave unmixed with others is a difficult task. With variations in textile operations a constant supply is also often impossible to assure.

Many attempts have been made to find substitutes for the fabric base products. These have met with only slight success. Paper has been used in some cases. However, the impact strength is lower than is obtainable with fabrics and often other properties are not particularly good. A great deal of work has been done also on sisal, jute, hemp, flax, etc. These have generally been in the unwoven form. Sisal and jute, because of low price, appear at first glance particularly attractive. Their very high moisture absorption together with their peculiar structure makes waterproofing difficult. These properties have proved so disadvantageous as to entirely prevent their use. Attempts at waterproofing these fillers have either only served to slow down the *rate* of water absorption rather than the total amount, or else make the filler so brittle that it becomes useless. Many fillers, particularly those of tropical origin, such as palm, are tough and pliable only when moist. On thorough drying they become quite brittle. This property eliminates a large number of apparently strong fillers.

Nevertheless there is a great demand for fillers which will give improved impact strength and which will make materials that will be capable of molding in the same type of automatic equipment which now handles woodflour filled materials. Since bulkiness is one of the greatest difficulties to overcome, recourse has been had to pressing the fabric types between hot or cold calender rolls. While such a procedure results in some decrease of bulk, it is generally insufficient to balance the loss in strength due to fiber breakage. This fiber breakage is shown in Figs. 6 and 7 in which results of successive passage through even-speed calender rolls are shown. The loss of length will be noted. Where strength depends on fiber length as it most always does, this matter of fiber breakage is of greatest importance.

Fig. 6 shows an impact type of filler at the start of the compounding operation and gives a correct idea of the fiber length at this stage. Fig. 7 shows clearly the breakdown due to passage of the compounded material through calender rolls. This probably represents an extreme example of breakdown, but it is entirely within possibilities of commercial practice.

Asbestos

Asbestos is generally used where heat resistance is of primary consideration. While it has some abrasive drawbacks, these may be minimized by careful selection. The specific gravity of articles from such a filler is high and this also represents a handicap. Unless high strength, particularly impact strength, is required, short fiber asbestos is used. This is one of the few fillers giving a product which can be handled by the molder in the same type of equipment and molds as woodflour.

Many attempts have been made to substitute other mineral fillers for asbestos. This has usually failed due to their being non-fibrous and therefor giving a brittle molded piece. There is room for an improved heat resistant filler since asbestos loses strength on continued exposure to high temperatures. Such a filler must, however, sacrifice none of the strength properties of asbestos.

Mica

It is not surprising that this mineral which has been known so long because of its low loss electrical properties, should be used as a filler for this same purpose. In the older type of usage, the mica in plates was built up by laminations to the required thickness and shape. In molding materials the mica is ground to a relatively fine mesh and used just as any other filler. In both cases careful selection is necessary particularly to eliminate the presence of harmful impurities which affect the electrical properties. The type of resin used also exerts a marked effect on final properties.

Graphite

Graphite is often added to molding materials for the obvious purpose of providing lowered frictional resistance, especially in the dry state.

Summary

The primary and secondary requirements for fillers for thermosetting molding materials have been given and their importance explained. The good and poor characteristics of some of the common types have been discussed. The great difference in filler requirements of rubber and thermosetting resins is stressed. This centers chiefly around the *fibrous* nature of thermosetting fillers.

It has further been stressed that fillers for the plastics molding industry must meet a combination of rigid requirements. Substitutes offered to replace present fillers must give as good properties at lower cost or better properties at same cost.

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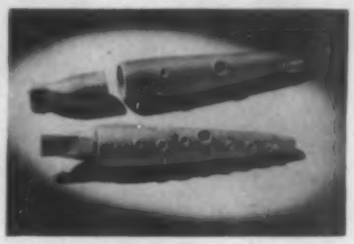

Swanson Tonette molded for the Chicago Musical Instrument Co. Chicago

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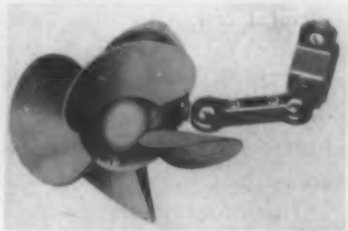

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FURFURAL PHENOL COMPOUNDS

(*Continued from page 32*) molding face, with no side confinement, in the same platen openings with printing plates carrying only newspaper screens, zinc cuts and type matter, and during one molding operation producing approximately one thousand two hundred and eighty square inches of miscellaneous printing plate matter, with a cure time of two minutes and plates removed from the molds hot. Under these conditions the regularities, including even the minute variations in surface polish, the usual regularities and irregularities of a printing surface, the trueness of height of printing portions and a uniform moldability of sharp and also rounded non-printing portions had to be carried out with little or no dimensional or surface finish tolerance.

Heat resistant products are largely made of furfural resins. These resins, when used with inorganic fillers, for example asbestos, provide a heat resisting part such as handles which have been subjected to rising temperature up to 450 deg. F. without elongation and without blistering. Furfural resins are indeed most desirable for heat resistant work inasmuch as the products not only do not elongate and blister, but are rigid when hot or lack thermoplasticity at elevated temperatures.

Where warpage even after molding is a consideration, furfural resins are given immediate consideration inasmuch as furfural resins leave the mold in a rigid set piece of close dimensional accuracy and in the cooling, outside of the molding cavity, the change in dimensions is uniform and may be definitely controlled without resorting to special cooling agents, etc.

This brings us to another type of furfural resin wherein the reaction is so carried out as to provide a product which at room temperature is flexible, oil resistant, infusible and has a tough rubbery characteristic. This infusible product is moldable and may be hardened to a rigid ultimate body by various molding methods. This rubbery type of material, which no longer melts, can be formed into shape with no further polymerization.

Molding methods

Furfural resins and furfural with resins are useful commercially in many molding methods which will be briefly discussed in the following paragraphs.

Cold molding. Cold molding of furfural resins, with furfural preferably in excess or furfural used with resins, is being utilized in large scale daily production inasmuch as furfural is an excellent resin solvent and plasticizer and hardening agent and is capable of resinification of itself. In cold molding the product containing furfural is coated onto the surfaces of various fillers usually inorganic, occasionally organic, or a mixture of these. A number of methods are utilized for the purpose of converting these wet mixes to a dry granular pourable mix. Lowering the temperature of a composition while the mix is in motion solidifies the resin and the product is no longer wet and therefore may be readily poured into a mold, levelled, cold pressed and subsequently cured.

By heat treating the coated filler while in motion at a relatively low temperature to bring about further reaction and to convert the liquid resin to a dry solid resin at room temperature, there is likewise produced a dry granular mix which may be cold molded and subsequently hardened.

To the coated filler dry pulverized resin is added in a quantity sufficient to impinge onto the sticky surfaces of the resin coated filler providing a dry granular mix. The proportion of dry resin, however, must be closely balanced in order that the percentage of vagrant unsuspended resin be as low as possible, otherwise the mixture will lack uniformity from the standpoint of resin distribution. The impingement or suspension of pulverized resin particles on the resin coated filler surfaces again provides a dry granular mix.

An improvement comprises the use of a special liquid resin which is coated onto the filler in sufficient quantity to provide a relatively wet mix even when a quantity of pulverized solid fusible resin has been added. The mix therefore is wet and there is no vagrant resin. A chemical interaction between the liquid resin and the pulverized resin quickly converts the composition to a dry granular mix, this change taking place about as soon as the mixing and screening have been completed. This self-converted dry granular mix is then placed into molds, levelled, pressed and subsequently hardened.

Unconfined molding. Furfural resins and molding compositions are provided with a restricted flow and therefore the molding is carried on through heat and uni-directional pressure without side confinement. This type of molding is particularly applicable for flat sheet-like work where the ornamentation varies with each piece or every few pieces and where the mold or matrix offers relatively low compression resistance. This process is particularly used in the manufacture of printing plates, their matrices, embossing plates and other flat ornamental products. The matrix is usually metal faced being backed with a non-yielding synthetic resin or else of soft lead and these matrices are reproduced from the original printing type form, plate or etching. The matrices have a smooth level back with the printing depth impressed therein represented by a fixed dimension to such back. These are placed on an open grid and the pulverized fusible furfural resin applied to the face. Any number of matrices so powdered are placed on a steel plate to fill the capacity of the platen opening of the press. The platens, heated to approximately 320 deg. F., are closed slowly to the stops, the excess of furfural resin, the volumetric requirements of which could not economically be determined, flows laterally through the unconfined openings, the press is kept closed for a period of about two minutes, and the plates, a perfect replica of the matrix are now removed while hot and after trimming are ready for use either for stereotyping, hot or cold, or for direct printing.

Transfer molding. Furfural resins were the first in use for transfer molding. The composition flows freely and even though free-flowing attains high strength. The furfural resins have been placed into the pressure chamber of a transfer molding press assembly which was utilized

as a material reservoir and a large number of duplicate pieces were molded over a period of forty-five minutes when the supply of material in the chamber was exhausted. Furfural resins therefore are of interest not only for transfer, but likewise for injection and furthermore for extrusion molding.

Uses

These uses are most diverse as furfural resins may be manipulated or molded in so many ways, but the particular type of product may have developed for it a special method of molding to attain particular objectives. Furfural resins themselves even when applied with a brush or sprayed onto wood or metal surfaces produce indurated products of increased resistance and improved electrical qualities. These products are being used even to the extent of coating reaction vessels, food containers and containers for various beverages, paints, varnishes and other chemical products which require for various reasons freedom from contact with the metal forming the container or can. These coatings are indeed enduring as tests have been carried out in connection with metal beer barrels coated internally with furfural resin which have withstood rough usage and repeated steam sterilization for a period equivalent to several years of use. Coatings applied to stucco have been under test for a period of two years under a constant head pressure of water and there has been no seepage or penetration. Aluminum housings for instrument cases, as for example those used in dairy and dairy product plants, are subjected several times daily to strong alkaline cleansers and a mere air-dried coating of these resins has withstood such treatment for a period of years.

As "proofing" for cloth, paper, etc., providing thin flexible films which may be air-dried or oven-dried it is possible to produce waterproof curtains, raincoats and other such proofed products which have practically the flexibility of the original cloth and the proofness of heavy rubber treated fabrics. As coatings too it is possible to apply coatings containing various fillers and gritty products through the use of furfural resins onto paper and cloth as in the production of waterproofed abrasives, etc.

Penetrating these furfural liquids beyond the surface as in impregnation it is possible to indurate many open porous bodies, thus reducing moisture absorption, providing increased toughness and strength and if desired dielectric properties. As examples of this, various soft woods are being ebonized for piano keys, cutlery handles, etc. Plaster of Paris molds and forms are being indurated and strengthened for molding and casting of various products thereof. These products while strong and tough may readily be hardened and polished even though made of brittle fragile plaster.

The preceding paragraphs under "Uses" dealt particularly with film forming impregnation which could be merely air-dried, heat-hardened or hardened and set under the combined action of heat and pressure. In the following paragraphs we will consider from the standpoint of uses cold molding, unconfined molding, hot confined molding, transfer molding including injection and extrusion, and finally blowing.

Cold molding. Cold molded furfural resins are being utilized in the production of various mechanical and electrical parts usually comprising inorganic fillers. However, in some cases a combination of inorganic with organic filler is used and in rare special instances inorganic fillers alone are used. The products are surprisingly strong and the fact that furfural has a high boiling point and for that matter does not tend to boil but rather react with the ingredients of the resin, the finish is exceptionally good. The strength of the product may also be kept up to a very high tolerance limit. This can best be exemplified as in the production of cut-off abrasive wheels which though of a thickness of only $^1/_8$ in. and a diameter of 18 in. or over may be test operated at the surprising peripheral speed of 25,000, and an every day operating speed of 15,000 surface feet per minute. The centrifugal force and resistance under work is such that the product must be of exceptional strength to be usable for this purpose. For many uses under cold molding it would not be possible to practice hot molding technique. For example in the manufacture of abrasive wheels of large diameter and thick cross section, a hot molded piece would be uneconomical from a mold cost standpoint and furthermore if completely set and hardened in the mold it would not be possible to remove such abrasive body without destroying either the molded piece or the mold ring.

Under some conditions the cold molding operation is practically equivalent to trowelling in that cold molding cementitious material including the binder is merely placed in position and then hardened. Under this hardening further adhesions may take place, as for example in the use of furfural resins as a cement for the purpose of bonding the brass ferrule of the incandescent lamp to the glass bulb of the lamp. These cements must cure quickly, must adhere to both metal and glass and must be resistant to moisture and heat. Some of these lamps burn at very high temperatures and the furfural resins are capable of withstanding such temperatures and even when hot the adhesion of the glass to the metal is excellent.

The excellent finish of many of the cold molded pieces has been developed to such high efficiency that these methods may now be practiced in the production of buttons, buckles, etc., wherein the surface finish of the buttons when subsequently hardened is very close to the surface finish of a button molded under heat and pressure.

Unconfined molding. We have already stressed the manufacture of printing plates, matrices, embossing plates and various ornamentation of a flat nature. This field is a large one and furfural resins are ideally suited for this purpose inasmuch as molds of relatively weak mechanical strength may be utilized to provide a substantial number of duplications.

Under the method of utilizing infusible molding materials and the use of furfural resin and furfural resin materials, the pressures can be greater and the number of duplications from a mold likewise greater. Thus further advantages accrue through the use of this novel char-

acteristic of furfural resins, which though infusible are capable of cohesion into a homogeneous body.

Hot confined molding. The number of parts molded by these conventional methods include parts for mechanical and electrical devices of various types and are usable in almost all industries. There is no limitation as to uses within the automotive and electrical industries inasmuch as various furfural resins can be provided which have exceptional strength and electrical insulating properties, have a high frictional coefficient and therefore are useful in brake linings and have a finish and color stability which makes the products useful for various other mechanical and ornamental uses.

Transfer molding. This should be assumed as referring likewise to injection and extrusion molding. These three terms should not be considered as synonymous, as there is a considerable difference in each of these methods.

Under transfer molding many diverse products have been made, mold cost may be low and dimensional accuracy may be attained with great uniformity. Under this manner of molding it is possible to produce parts which the usual brute force methods of heat and pressure molding do not permit. In this article it is possible to describe only a few of the applications because of space limitation. The statement, however, can be made that the process for certain special uses may be operated to economically produce those few or those unusual pieces which the heat and pressure method of molding could not provide economically if at all.

Under injection molding various parts are being made, the particular objective being a low mold cost due to the low number of mold cavities required and a relatively high per diem production from the mold cavities provided. This together with economy in labor and supervisory costs makes injection molding of particular interest for many uses. It is the automatic mechanical feature of precise chronological precision which makes this process of exceptional interest. The latitude obtained in furfural resins makes them of interest for certain of these injection moldings, particularly where dark colors, great strength and infusibility are requirements.

Extrusion molding makes possible the production of pipe, rods and various shaped pieces having substantial length, but heretofore synthetic resins as a general class have not been as extensively used for this type of molding as have the rubber compositions. This type of molding calls for a composition which is substantially rubbery and the furfural resins can provide such composition even to the point of infusibility. Furthermore, infusibility of furfural resins when so molded and the fact that these resins may be plastic even though cold or but slightly warm simplifies extrusion molding very materially. It is possible to cast a lead sheath around the extruded furfural resin formed composition and the composition as then encased is substantially a lead mold which shrinks on providing smoothness, polish, dimensional accuracy and under some conditions additional pressure. This assembly may then be heated, the temperature gradient of the oven steep and subsequently the lead sheath stripped from the molded part, thus providing an endless length of strip material ready to be used.

Blowing. By "blowing" it is possible to fabricate many of the articles which had previously been made of cellulose nitrate and rubber. With a special flexible rubbery type furfural resin, used either in homogeneous or sheet form with or without fillers, or when products are "proofed," that is, coated or impregnated into sheet-like bodies, the possible applications are indeed numerous as the mold cost is low. Ordinary cast molds and for some purposes even molds of wood and plaster of Paris will answer the purpose. The applications are particularly those requiring complex or complete coring of the article. Furthermore, the application is useful for the molding of relatively large parts with the assurance that a uniform hydrostatic pressure will be had on all portions of the parts molded and that the material in its required cross section is in place and requires only pressure sufficient to contact with the surface forming portion of the mold to provide the finished part. More specifically then, we can include toys, hollow balls, lining of chemical vessels and digesters, production of piping, rods, tubes, etc., or the lining of piping, valves, elbows, etc. In the matter of relatively large pieces of a more or less proprietary nature we might mention toilet seats and covers, toilet floats, parts for hydraulic rams and the production of chemical ware. Among uses of a more general nature we may include airplane propellers which may be cored with an exactitude to provide not only the smooth accurate pitch of the exterior, but a uniform core on the interior to reduce weight. The production of waterproof wings and bodies may be carried out economically because of low mold cost and low material requirements and a precise quick means of molding. This brings into consideration also automobile parts for interior and exterior trim; the doors, fenders and the bodies themselves could be molded readily through the use of sheet-like infusible rubbery furfural resins.

Conclusion

While this issue of Modern Plastics will include a Plastics Properties Chart, the molder and user of synthetic resins should understand that this chart while representing maximum and minimum figures cannot represent the varied types of products which are being produced in resins containing furfural and that therefore each specific use should be considered carefully in conjunction with the resin manufacturer and molder to determine upon the best type of product to suit the particular requirements of the part being made.

Each year since 1920 has seen new developments and improvements in the processing of resins containing furfural. It is believed that furfural, the unusual anhydrous aldehyde of high molecular weight, with its many friendly hands of linkage, will extend these hands to industry to a greater and greater extent each year and continue the many friendships resins containing furfural have formed in the past through accomplishment, adding many more friends who will be staunch supporters of furfural resins upon becoming familiar with their varied but uniform characteristics.

INJECTION MOLDING

(*Continued from page 33*) is determined by price, molding characteristics, yield of molded pieces per hour, strength and aging characteristics of molded article. As a rule the line of least resistance is to choose a molding material which gives the maximum production with a given machine or mold. The second stage is the use of a quality material, which, while suitable to the machine or mold, gives the most desirable properties of the final molded article. Different types of molding materials have been developed to meet the exacting requirements of the art, bearing in mind that however complete and perfect the molding machine and molding control might be, good molding cannot be achieved unless the molding material is particularly adapted to the process. Variation in type and quantity of plasticizers and base-material permit the formulation of molding materials with a wide range of physical characteristics and moldability or degree of flow. Thus, for a particular article there is a formulation which is best suited to the physical requirements of the article and the method by which it is to be molded.

Injection Molding Technique

In last year's October issue of Modern Plastics, Minnium in an excellent article thoroughly covered the technique of injection molding. To his thorough analysis of molding hardly anything can be added from the standpoint of molding technique. In order to obtain optimum results in injection molding of thermoplastic material it is necessary to realize that the injection molding procedure may be compared to an orchestra with many instruments. Each instrument has to be tuned properly to produce a final satisfactory harmony. The various instruments are as follows: Plastifying temperature, plastifying time, injection pressure, injection speed, clamping pressure, setting time in mold and mold temperature. Change of one of these factors may upset all the others and the result is dissonance. Consequently the secret of good injection molding is as follows: Set conditions right and keep them constant. This cannot be done unless the machines are fully equipped with instruments to show obtaining conditions. The less changes of colors, molds or conditions that have to be made the more profitable the molding.

Mold Design

Great progress has been made during the past year in design of molds. While the general principles of design have been discussed elsewhere in this journal, it is only necessary to mention that a better understanding has been arrived at concerning size and dimensions of sprues, runners and gates in relation to the final article. Finishing costs are continuously being reduced. Sharp corners, welds, uneven wall thickness, combination of thick and thin sections, large flat surfaces, etc., still cause difficulties; yet results obtained today are definitely better than one year ago. One factor which will require additional study is mold shrinkage of different materials and degrees of flow in relation to size and shape of the molded article. Generally speaking mold design has developed hand in hand with improvement in machine design, molding material composition and molding technique.

Color

One of the main advantages of using thermoplastic materials in injection molding is the wide range of transparent, translucent, opaque, plain colors, bronze, scale and essence pearls, as well as variegations and mottles available for this process. Some of the thermoplastic materials are more heat stable than others with a resulting difference in color stability and discoloration of the final molded article.

Great strides have been made in the art of formulating and molding of injection molded mottles and variegations. The character of injection molding mottles, in addition to the effect of color components, is largely determined by hardness and granulation size of components, cross section of article, location of gate, as well as size of sprue and nozzle bushing. The shorter the flow the more distinct the mottling. (*Please turn to next page*)

Four electric razor heads plus four disks (lower left) are molded at one injection with greater speed than they could be die cast or machined from any other material. Molded of Tenite by Gits Molding Corp. as are the Faith Traphagen golf club ferrules (center). The Obite fish lures at the right are molded of Tenite by Sobenite, Inc., for South Bend Company

CHART #1

PLASTICITY VERSUS TEMPERATURE

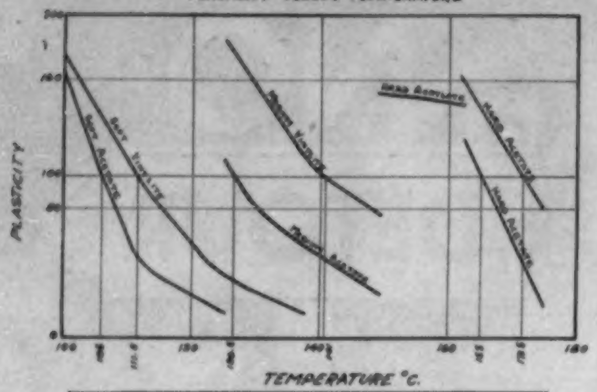


CHART #2

SETTING TIME OF INJECTION MOULDED ACETATE PLASTICS

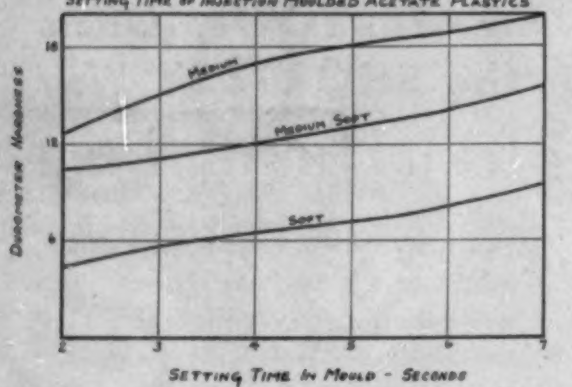
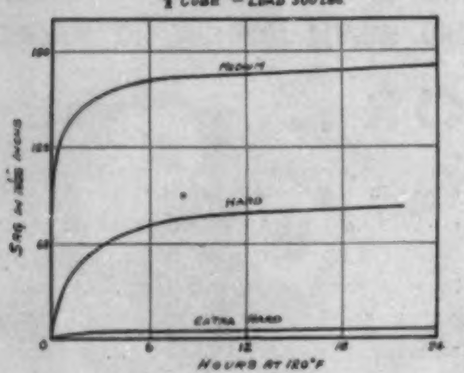


CHART #3

COLD FLOW OF INJECTION MOULDED ACETATE PLASTICS

1" CUBE — LOAD 500 LBS



Tests and Specifications

Testing of molding composition as well as the final molded article has become more and more important during the past year. Methods of testing both the material and the molded article, are, therefore, important aids in drawing up specifications for a material which will best meet the demands of the application in question. It is necessary to differentiate between the testing of and specifications for the base material and those for the final molded article. Testing of the molding composition will determine whether or not material is suitable for the particular application. Testing of the final molded article will reveal whether or not the proper material specified has been used and whether or not optimum molding conditions have been adhered to.

From the standpoint of injection machine design we differentiate between the injection end and mold closing end, plastifying the molding composition by means of heat and injecting it into the mold, and clamping the mold so that the plastic material is confined within the mold during chilling and setting without opening the mold. Material suppliers, to accommodate injection end and mold clamping ends of machines, have developed easier flowing and faster setting materials to tie in with this development. Chart 1 shows the temperature-plasticity curves of a series of thermoplastic materials used for injection molding, both resins and cellulose acetate plastics, ranging from very soft to very hard. If we choose a plasticity of 100 as a common denominator in order to differentiate between these plastics, we will note that they all, under certain conditions, will give the same flow and consequently may be handled in present types of machines from standpoint of flow. Only the softest requires a temperature of 106 deg. C., while the hardest requires 171.5 deg. C. in order to give equal flow.

The rapid development of injection molding machines during the past two years has multiplied the number of mold cavities used. Thus, the injection cycle is determined not only by ease of flow and rapid plastification of the molding composition, but also by time required to set or solidify in the mold. The larger the injection molded articles, the longer, obviously, it will take to chill it sufficiently to remove it from the mold. Considering the setting time, the second cycle regulating factor, considerable variation will occur with different plastics. Chart 2 shows a series of setting curves of cellulose acetate plastic, plotting time of setting in mold against Durometer hardness. (Type D needlepoint for hard rubber.) The minimum hardness at which the article could be removed from the mold without sticking under the conditions of the test was 12. If we choose this figure as a base for comparison, it will be noted that the medium material could be removed in less than 2 seconds, the medium soft in 4 seconds, while the soft material required more than 8 seconds. Thus, by balancing the flow against setting time, it is possibly to select a material which gives the optimum molding cycles for a given application.

In a number of instances the aim in injection molding is to produce articles having the properties of thermosetting plastics. These materials have the advantage of low cold flow, high softening temperature, high hardness, etc. By proper formulation some of the thermoplastic materials may be formulated so as to approach the heat resisting properties of thermosetting materials. Chart 3 shows a cold flow comparison of three types of cellulose acetate plastic. It will be noted that the extra hard type gives a cold flow curve of the same type as usually obtained with thermosetting materials. Test pieces were made by injection molding. This material also stood boiling water for one-half hour, and was removed from the mold at 265 deg. F., without showing any distortion when cooling at room temperature. This type of thermoplastic material, undoubtedly, will come more and more to the fore in the future.

ORGANIC COLD MOLDING

(*Continued from page 34*) Then in this varnish-like condition, asbestos is incorporated by feeding the mass through mixing or kneading machines. The resulting asbestos impregnated mixture is dried to the proper condition and molded in cold molds. Moldings are not finished when they come from the press but must be dried or baked in suitable ovens at properly controlled temperatures until the desired degree of hardness is obtained.

Three basic principles were followed in working out the organic cold molding process:

(1) *Preparation of the solution:* One method of preparing the asphalt solution was to dissolve the asphalt or pitch in volatile solvents such as benzol or its homologues to facilitate the evaporation or drying process after molding. The procedure was based on the making of a quick-drying asphalt paint. Another method, which has since proved more practical and which to this day is being followed, was to make the asphalt solution on the basis of an oven-drying varnish by dissolving the asphalts in suitable organic or mineral oils.

(2) *Conditioning of Asbestos-Asphalt solution mixtures for molding:* In this respect, the procedure of porcelain molding was basically adopted. That is: The asbestos-asphalt mixture had to be in just the right physical condition, not too dry, not too wet, to be transferred into the mold. It had to be soft enough to be molded to proper shape without too high pressure yet it had to have sufficient stiffness to permit its removal from the mold without deforming its shape. If the material was too stiff it had a tendency to stick to the mold and make a fast molding cycle uncertain.

(3) *Baking or hardening after pressing:* Here, too, well established procedures were followed in the early stages of development. The baking of the cold molded articles in ovens at temperatures up to 200 deg. C. corresponded in a way to the firing of clay (porcelain) molded parts. But in the case of cold molded products, the baking had no fusing action to perform, merely an action to eliminate the volatile solvents from the asphalt or other resinous solutions and to perform an oxidation of oil solvents, thereby drying or hardening the asphalt (organic) base, exactly as in the procedure of oil baking asphalt or gum varnishes.

Few changes in the compounding of cold molding mixtures, molding and baking methods have been made since introducing the process in this country, although a variety of formulas have been worked out by individual plants. Various grades of asbestos, oil, asphalts, coal tar pitches, stearin pitches, copal gums and the like with their solvents and drying-oils such as linseed oil, china wood oils, castor oil, soybean oils, etc., with or without the addition of drying agents have been used.

Molds and Presses

The type of molds has not changed much from the beginning. They are mostly single cavity, but improvements in steel used in making the molds, due to the high abrasive action of high asbestos content in cold molding compositions, have been a factor of real progress.

The type of presses used are primarily of hydraulic action although some toggle action presses are used to advantage in some cold molding plants for making small articles. For large pieces and for deep drawn molded parts, the hydraulic presses are still better suited and are in general use today.

In the earlier development stages of organic cold molding materials, and I refer to the work of several cold molding plants abroad, the main difficulty of successful molding was in the conditioning of the mixture. As a matter of fact, at that time, no definite practical factor of standard was ever attained. Even today, this condition exists to a limited degree. (*Please turn to next page*)

Cold moldings have the advantage of high heat resistance and, usually, great mechanical strength. Savings are often effected because they are usually turned out in single cavity molds. (Photo courtesy Cutler Hammer)

Unlike hot molding materials which are prepared on hot rolls and rendered into a definite hard, dry condition ready to be molded by softening with heat, thereby becoming really plastic for pressure action, cold molding mixture depends upon the action of pressure for molding and too high pressures are likely to damage the molds. Therefore, the proper combination of drying oils with asphalts or resins, together with the asbestos body is of vital importance.

Yet, since this condition of proper permanency of the molding mixture cannot be definitely maintained due to different atmospheric conditions or climatic changes, oxidizing action of the air will and must affect the semi-plastic molding material in two ways. If the oxidation or drying action goes too far before the material is molded, too much pressure on the mold is required and damage may result. On the other hand, if the mixture is too soft, i. e., not properly conditioned or dried, a molded part of porous warped condition and inferior mechanical strength will result.

This condition of processing difficulty has been responsible to a great extent for the replacement of cold molded parts with hot molded phenolic products which in molding under heat and pressure give the molded piece more definite uniformity both in appearance and in mechanical strength. Furthermore, hot molded phenolics require pressures of but 2000 to 4000 lbs. per sq. in. while cold molding pressures required may vary from 5000 lbs. to 25,000 lbs. per square inch.

The reason why cold molding materials have never been placed on the market for general distribution like other plastic materials is because they oxidize rather quickly even when stored in air-tight drums. For this reason, only limited quantities of the materials can be prepared in advance even in the plants where they are used every day. The conditioning of such mixtures, which depend upon hardening or drying after molding, has been worked out in commercial practice so as to coordinate the time of storing sufficient mixed material on the premises for some limited length of time, but not to the extent where they can be shipped for processing other than in the plant of their origin.

This limitation of preparing cold molding mixtures and molding them in the same plant has been another contributing factor in restricting their general use even in applications where their physical characteristics may be superior to other materials. Cold molding equipment is costly to begin with, and requires delicate manual skill to operate with any degree of success. A molder of cold molding materials must not only know how to get the best results from every mechanical detail of his press but must know how to mix and maintain his materials at the proper consistency as well. This naturally gives a distinct advantage to standarized chemical compounds which can be hot molded into continuously identical parts once the molding cycle and curing time has been definitely determined.

The production of cold molding materials in this country today is probably not more than 25 percent of its volume ten years ago. Nevertheless, these materials will always command a definite field, especially in the electrical arts where high heat resistance and other conditions are better accomplished with cold molded parts than with phenolics or ureas. This superiority over other materials, however, is due largely to the higher asbestos content (70 to 80 percent) possible in cold molding compounds, as compared with 20 to 50 percent in phenolics. It is the smaller percentage of organic resinous binders (20 to 30 percent) in cold molded compositions as against 40 to 50 percent resinous binders in phenolics which gives cold molded materials the higher heat resisting advantages. But, in the writer's opinion, the possibility of increasing the heat resisting properties of hot molding phenolic compounds by increasing the percentage of asbestos content will bring the heat resisting features nearer to those of cold molded products. The only question is, will the synthetic polymerized resin stand less or more heat than the dried or oxidized asphalt resin oil combination.

In the writer's opinion and from my own experience, there will be only small factors of difference (if any) in heat resistance between the phenol binding resin and the natural organic cold molding resin. Provided, of course, that the curing time and temperature in hot molding is sufficient to polymerize the synthetic resin to its final stage.

Cost factors of raw materials and slower curing time in hot molding will, of course, affect costs and still give cold molding some advantage in this respect. On the other hand, with the same percentage of limited proportion of resinous binder, the hot molded phenolic material will have greater mechanical strength due to the fact that the phenolic resin is mechanically stronger and tougher than the dried or oxidized natural resinous binder.

Having recognized this advantage of mechanical strength and toughness inherent in phenol-formaldehyde resins years ago, the writer adopted a certain type of such resin solution as a binder for asbestos following the same procedure as with asphalt-oil-resin binders in cold molding compounds. This resulted in a stronger cold molded product and practically all cold molding plants have turned out various grades of such phenolic cold molded composition. While such products have found a number of successful applications their use has been limited by the same difficulties and delicate conditioning requirements mentioned before.

The one remaining advantage of cold molding materials and parts over other materials and their products in the plastics field today is *heat resistance*. If, and when, phenolics or other synthetic resins are compounded with equal heat resistance through elimination of wood flour and increased percentages of asbestos, even this advantage will disappear. While certain improvements in appearance, heat resistance, and strength have been made in cold molded products during the last few years, the basic principle of advantages and the improvements made in hot molding phenolic materials in this respect will almost certainly, in this writer's opinion, offset the superiority of even these late grades of organic cold molding compounds.

Eliminating frantic searches through drawers and on closet shelves, these boxes of Plastacele, a lightweight cellulose acetate plastic, keep shirts, ties, shoes, gloves and other accessories fresh and neatly segregated. (Photo courtesy du Pont)

CELLULOSE ACETATE

(*Continued from page 21*) in addition to being a necessary part of its mechanism.

The strength of cellulose acetate plastics made them a desirable selection for steering wheels from the standpoint of the engineers, although this was by no means the only qualification needed to make them practical. It was the resilience of these materials which determined their suitability for this purpose. The molder was faced with the great difference in thermal expansion between a plastic coating and the steel insert. The standard test for molded wheels is to place them in a temperature of minus 40 deg. C. for a period of 48 to 72 hours and then expose them to room temperature. Since the coefficient of expansion of steel is approximately 0.000010 in. and that of cellulose acetate is 0.00016 in. per degree Centigrade, there is an expansion of about $^1/_2$ in. in the 52 in. wheel circumference when changed from an atmosphere of minus 40 deg. C. to room temperature. This means, of course, that there would be every tendency for the coating to crack when submitted to this admittedly severe test. Only by using a very resilient formulation could this condition be prevented.

This resistance to breakage is of equal importance in the molded escutcheons, some of which are relatively thin-walled. Here the material is subjected to pressure and strain both in the process of assembly and in usage, and therefore must undergo severe tests of strength before it can be accepted. One test is to drop a 2 lb. weight on the escutcheon from a height of 8 in. If an escutcheon can withstand 8 of these blows without cracking or becoming distorted it is considered adequate for the job which it must perform.

Modern radio cabinets are equipped with a number of cellulose acetate parts illustrating some interesting molding jobs. Probably the most intricate are the bezels, injection molded around glass. The manufacturer in this instance wanted three things: 1. Color—not a match for the wooden cabinet but a harmonizing effect; 2. A part which, for economical reasons, could be easily and quickly assembled; 3. A part which would eliminate metallic noises caused by vibration.

The answer to the first requirement is easily found in cellulose acetate variegations obtained by mixing light and dark brown granulations in the desired proportion, or by using a brown-cream variegation. These effects blend with the color of the cabinet and yet have sufficient depth of their own to enhance its general appearance.

The cellulose acetate plastic is injected directly around the rim of the glass, a most ingenious means being used for positioning the insert. By molding projecting lugs on the back side of the piece, the manufacturer can easily fasten the finished bezel to the cabinet with speed nuts.

The answer to the third requirement is partially supplied by the material itself which is non-resonant. Also, by molding the plastic around the glass so that the two become the equivalent of one piece, vibration and rattling are prevented.

Plastic knobs of the same color as the bezel are used to carry out the decorative scheme of the cabinet. These would seem to be simple parts to mold and yet they too presented some difficulties to the molders. Aside from the relatively large amount of material contained in the knobs, production was slow because the thick section of the knobs prevented quick cooling, or "setting," in the mold. At this rate, the knobs were too expensive to be practical. However, by coring them to cut down on material, and thereby making the cross sectional area much thinner, production time was cut and costs reduced. Molded grilles and dials have also been adopted because of their strength and decorative value.

These new types of bezels and knobs, developed primarily for the radio industry, were quickly appreciated

by the refrigerator companies and adapted for use on the modern electric refrigerator. Not content with availing themselves of the molded parts already on the market, however, the refrigerator people experimented with cellulose acetate for shelf lugs, which had heretofore been made of metal and other types of plastics. This experiment proved highly successful in that the noise made by the shelves in sliding over metal lugs was eliminated, as well as the risk of breakage in lugs molded of other plastic materials.

So far, we have seen cellulose acetate plastic knobs preferred to those of other materials for automobiles, radios and refrigerators. It should not be inferred from this, however, that the practicability of this plastic is limited to small sized knobs. It is being used with equal success by building hardware manufacturers for door knobs and handles of various types. These are not uncommonly molded around metal inserts, a process which provides production economies in the manufacture of these commodities and gives added sales appeal to the finished products. The metal furnishes the desired rigidity while the plastic covering eliminates such finishing operations as are required in knobs and handles constructed entirely of metal. The plastic also enhances the appearance of the product by contributing color which cannot chip or crack, and a luster which is permanent.

The combination of plastic and metal is one which is employed in almost every field of industry where these plastics have penetrated. An interesting example is found in a novel type of fuel oil gage. The selection of a cellulose acetate plastic for this application was occasioned by still different requirements from those cited in the foregoing illustrations. It was of prime importance that the material be practically non-inflammable and non-breakable. Next, a mold had to be devised in which the spun aluminum head of the gage would act as a metal insert for the molded plastic. The plastic was then injected around the head in such a way as to produce an hermetically sealed unit. A clear transparent plastic was used to permit legibility of the gage figures. This ingenious design not only improved the appearance of the article but also made it leak-proof.

The uses of transparent plastics are, for the most part, confined to industrial applications, like that just described, where it is necessary to have a protective covering which provides visibility. There are, of course, some applications quite outside the industrial field where this transparent protective material is used, and among these we find some very cleverly designed fish lures. One rather complicated but effective bait is composed of a molded body divided into two sections. The lower section contains a live bait and water, while the upper one, containing only air, provides the necessary buoyancy. Still other transparent lures are lacquered in spots to give them a life-like appearance in the water.

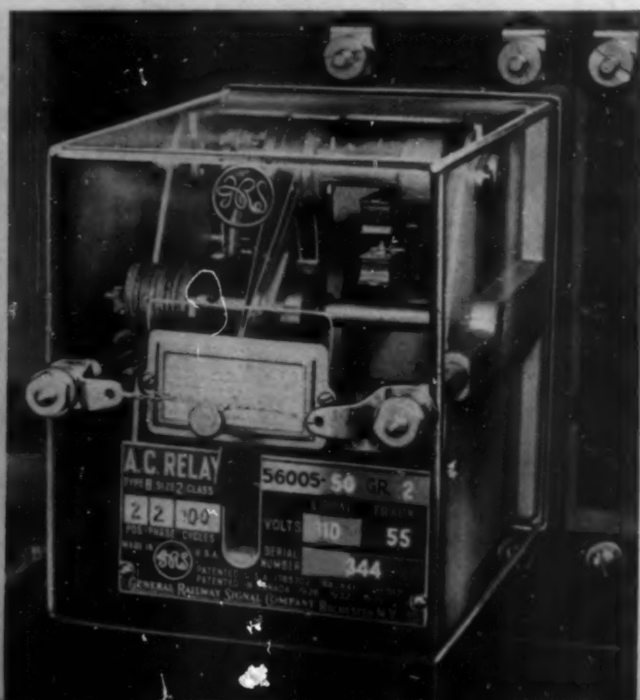
Speaking of sporting equipment, cellulose acetate molded golf tees, although not guaranteed to better your score, are rather widely used. The strength of the material and its adaptability to injection molding recommend it for this rather unusual application, as well as for golf club ferrules and shaft tips.

If target shooting or hunting is your favorite sport, your pistol grip, trigger guard, or gun butt may well be molded of cellulose acetate plastic. Its pleasant "feel" and resistance to breakage have influenced manufacturers to adopt it for handles of all types.

It would be hard to find a better material than this for toys. Such articles as toy automobiles, airplanes, whistles, and pistols, when molded of cellulose acetate plastics, are practically unbreakable, non-hazardous with respect to fire, and colorfully attractive. Molded by the rapid injection process, they have the additional advantage of being inexpensive.

Manufacturers of games, such as dominoes, checkers, chess, and Mah Jong are finding that their products can be made more attractive and more salable through the

In diving and darting, these Tenite fish lures (left) have true, life-like action in water. Tenite in place of wood insures uniform weight and proper balance. At the right is a relay case with transparent cover molded from Monsanto CAM (cellulose acetate molding powder) by General Railway Signal Co.



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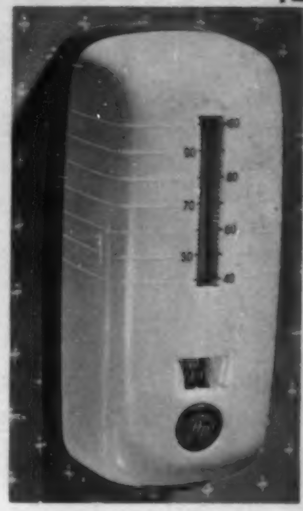

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Q. What is the effect of weak acids on vinyl chloride, acetate resins, unfilled?

Q. What are the color possibilities of shellac compounds?

Q. What is the percentage of elongation of cellulose acetates in sheet form?

HAVE ALL THESE FACTS AT YOUR FINGER TIPS!!

They are contained in the PLASTIC PROPERTIES CHART, published by Modern Plastics . . . reprints of which are available.

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Bright Star Battery Co. uses Lumarith for these flash-light cases because it neither dents nor chips with rough usage. Cellulose acetate is tough and resilient, and is never cold to the touch even in cold weather. (Photo courtesy Celluloid Corp.)

(Continued from preceding page)

use of plastics. The beauty of molded cellulose acetate poker chips gives an added pleasure to those who are lucky enough to have a stack in front of them at the end of a game.

Among all the products that have benefited by the invention of cellulose acetate plastics, those in the apparel accessory field are perhaps the most outstanding. Costume jewelry, in colors to go with every outfit and in designs to satisfy each individual taste, can now be purchased on chain store counters. Delicately and strikingly designed pins, clips, necklaces, bracelets, rings, and hair ornaments are items which everyone can afford. Hair combs to hold masses of curls on top of the head in the newest fashion, pocket combs, dressing table sets, and hair wavers are cellulose acetate articles which women have come to consider as essential. Slide fasteners molded of cellulose acetate plastics add a touch of color and decoration to the garments on which they are used. They are as washable and dry cleanable as the fabrics themselves, many of which are made of cellulose acetate rayon.

The astounding progress of cellulose acetate plastics is still unabated and we have every reason to believe that it will continue so for many years to come. With an increase in the size and capacity of injection molding machines, larger molded pieces will be possible at a faster rate of production. The trend is now toward the injection molding of harder formulas so that it will be possible for cellulose acetate plastics to penetrate those fields which are barred to them at the present time because of low heat resistance. Relatively small changes such as these are not far away, ready to open up new fields of operation for the material and product manufacturers. Ten years ago cellulose acetate plastics were practically unknown. What person dares to say he can prophesy the multitudinous uses to which they will be put a decade hence?

USING PLASTIC COLOR

(Continued from page 112) with the average furnishings.

Another special case are toys, running the gamut from gadgets for tots to elaborate gameboards for adults. The former naturally calls for the gayest brightest reds, blues and yellows you can get, but as you go up the age and income scale, colors should be toned down. For the whoopee type of toys and games, reds, blues and yellows will always be first choice, but the softened red cast phenolic backgammon discs show the need for subtlety as the mental intricacy of the game increases. At the top of this scale, we find the recently announced Autobridge—the top in mental exercise games—which employs an ivory urea base, ivory acetate fittings and black phenolic top in order to avoid any suggestion of hilarity in the sober business of studying bridge. Incidentally, Ely Culbertson of the Autobridge Company formed a jury of stylists and store buyers who picked this color combination in preference to the black and maroon toward which the company executives leaned.

One field which has used a great deal of plastics but not much color is Office Machines and Equipment. Aside from the fact that designs must look business-like there is no reason why colored plastics couldn't be used for accents and trim—to counteract the deadly dull look of most machines. For example, instead of the usual funereal adding machine or typewriter, one could try a blue-gray or taupe colored body—which would harmonize with any office decor—with perhaps a few fittings in bright red or green. Such a machine would attract eyes in windows and on purchasing agents' desks, would give salesmen new talking points and certainly would please the stenographer. It might even make her think that typing or computing is rather fun, after all.

Here's what colors mean in the opinion of some color authorities. But individual market peculiarities, competition or other associations can sometimes knock any one of them into a cocked hat, as can the use of certain shades, tints or modifications of each color.

RED:	Fire, heat, excitement, strength.
ROSE:	Daintiness, softness, fragrance, freshness.
ORANGE:	Warmth, action, power, tastiness.
MAROON:	Richness, solidity, luxury, quietness.
YELLOW:	Brightness, airiness, refreshment.
DARK BLUE:	Coldness, formality, haughtiness.
LIGHT BLUE:	Coolness, fragility, daintiness, youthfulness.
DARK GREEN:	Unhealthfulness, cheapness, coldness.
LIGHT GREEN	Freshness, crispness, coolness.
PURPLE:	Royalty, stateliness, opulence.
LAVENDER:	Fragrance, richness, refinement.
BROWN:	Wholesome and mellowness, utility.
GRAY:	Mildness, softness, reserve, primness.
WHITE:	Purity, professionalism, cleanliness, chastity.
BLACK:	Strength, mystery, heaviness, coldness.

The values for the properties in the accompanying chart are based upon maximum some cases if direct comparisons are attempted. Special grades c communication with the producers of these

PROPERTIES	PHENOL-FORMALDEHYDE COMPOUNDS							
	Molding				Laminated			Cast
	No Filler	Woodflour Filler	Mineral Filler	Fabric Filler	Paper Base	Fabric Base	Asbestos Cloth Base	No Filler
Molding Qualities	Fair	Excellent	Excellent to fair	Good to fair	—	—	—	—
Compression Molding Temp., °F.	300–340	280–360	270–350	270–330	250–365	250–365	250–325	—
Compression Molding Pressure, lbs. per sq. inch	2000–5000	1600–4500	1600–6000	3000–8000	1000–3000	1000–3000	1000–3000	—
Injection Molding Temp., °F.	—	275–375	275–350	—	—	—	—	—
Injection Molding Pressure, lbs. per sq. inch	—	2000–10000	2000–15000	—	—	—	—	—
Compression Ratio	2.0–2.6	2.2–3.0	2.0–7.1	2.5–11.0	1.5–3.0	1.5–3.0	—	—
Mold Shrinkage, inches per inch	0.009–0.011	0.006–0.010	0.002–0.006	0.003–0.007	—	—	—	—
Specific Gravity	1.28	1.25–1.52	1.70–2.09	1.37–1.40	1.34–1.55	1.34–1.55	1.6–1.65	1.27–1.32
Specific Volume, cubic inch per lb.	21.7	22.2–18.2	16.4–13.3	20.2–19.8	20.7–17.8	20.7–17.8	17.3–16.8	21.8–20.0
Refractive Index, N_D	—	—	—	—	—	—	—	1.5–1.7
Tensile Strength, lbs. per sq. inch	6000–9000	6000–11000	5000–10000	6500–8000	6000–13000	8000–12000	9000	5000–12000
Elongation, %	—	—	—	—	—	—	—	—
Modulus of Elasticity lbs. per sq. inch $\times 10^5$	7–10	10–15	10–45	7–12	5–20	5–15	—	5–15
Compressive Strength, lbs. per sq. inch	—	16000–36000	18000–36000	20000–32000	20000–40000	20000–44000	18000–40000	15000–30000
Flexural Strength, lbs. per sq. inch	12000–17000	8000–15000	8000–20000	10000–13000	13000–20000	13000–20000	17000	—
Impact Strength, ft. lbs. C = Charpy, I = Izod, N = notched, U = unnotched	0.16–0.20 I, N	0.10–0.28 I, N	0.11–0.36 I, N	0.4–2.4 I, N	0.4–1.2 I, N	0.8–5.2 I, N	—	0.1–1.5 I, N
Hardness (2.5 mm. ball, 25 kg. load), Brinell No.	—	30–45	—	—	24–40	30–45	—	30–45
Thermal Conductivity 10^{-4} cal. per sec. per sq. cm./1° C. per cm.	—	4–12	8–20	3–5	5–8	5–8	—	3–5
Specific Heat, cal. per °C. per gram	—	0.35–0.36	0.25–0.35	0.30–0.35	0.3–0.4	0.3–0.4	—	0.3–0.4
Thermal expansion, 10^{-5} per °C.	—	3.7–7.5	2.5–4	2–6	2	3	2	2.8
Resistance to Heat, °F. (continuous)	250	350	450	250–350	212–300	212–350	400–500	160
Softening Point, °F.	None	None	None	None	None	None	None	—
Distortion under Heat, °F.	240–260	240–285	—	—	>320	—	—	—
Tendency to Cold Flow	—	None	None	None	None	None	None	—
Volume Resistivity, ohm.-cms. (50% relative humidity)	$(1–5) \times 10^{12}$	$10^{10}–10^{12}$	$10^{9}–10^{11}$	$10^{9}–10^{11}$	$10^{11}–10^{13}$	$10^{10}–10^{12}$	—	$10^{9}–10^{14}$
Breakdown Voltage, 60 cycles, volts per mil (instantaneous)	400–500	300–500	250–400	300–450	400–1300	150–600	90	300–450
Dielectric Constant, 60 cycles	5–6	5–12	5–20	5–10	—	—	—	5–10
Dielectric Constant, 10^3 cycles	4–5	4–8	4.5–20	4.5–6	—	—	—	—
Dielectric Constant, 10^6 cycles	4.5–5	4.5–8	4.5–20	4.5–6	4–6	4.5–7	—	5–7
Power Factor, 60 cycles	0.05–0.10	0.04–0.30	0.10–0.30	0.08–0.30	—	—	—	0.025–0.20
Power Factor, 10^3 cycles	0.025–0.06	0.04–0.15	0.10–0.15	0.08–0.20	—	—	—	0.005–0.08
Power Factor, 10^6 cycles	0.015–0.04	0.035–0.1	0.005–0.10	0.04–0.10	0.02–0.05	0.02–0.08	—	0.01–0.045
Water Absorption, immersion—24 hrs.	0.1–0.2	0.2–0.6	0.01–0.3	1.0–1.3	0.5–9.0	0.5–9.0	0.5	0.01–0.5
Burning Rate	Very low	Very low	Nil	Approx. nil	Very low	Very low	Approx. nil	Very low
Effect of Age	None	←	←	←	Improves mechanical and electrical properties			Hardens slightly
Effect of Sunlight	Surface darkens slightly	Light shades discolor		←	Lowers surface resistance		←	Colors may fade
Effect of Weak Acids	None to slight depending on acid		←	←	←	←	←	←
Effect of Strong Acids	Decomposed by oxidizing acids; reducing and organic acids no effect				←	←	←	←
Effect of Weak Alkalies	Slight	Slight to marked depending on alkalinity				←	←	←
Effect of Strong Alkalies	Decomposed	←	←	←	←	←	←	←
Effect of Organic Solvents	None	None on bleed-proof materials			←	←	←	None
Effect on Metal Inserts	Inert	←	←	←	←	←	←	←
Machining Qualities	Fair	Fair to good	←	←	Fair to excellent		←	Excellent
Clarity	Transparent; translucent	Opaque	←	←	←	←	←	Transparent translucent opaque
Color Possibilities	Dark colors	Limited	←	←	←	←	←	Unlimited

PLASTICS PROPERTIES

upon maximum and minimum figures submit[illegible] by a number of manufacturers
pecial grades of materials are often available which excel in one particular pro
ucers of these materials, a list giving trade names and addresses for each of the

	Cast	PHENOL-FURFURAL COMPOUNDS			UREA-FORMALDEHYDE COMPOUND	VINYL CHLORIDE-ACETATE RESINS		METHYL METHACRYLATE RESIN	ST
stos th se	No Filler	Woodflour Filler	Mineral Filler	Fabric Filler	Alpha Cellulose Filler	Unfilled	Filled		
—	—	Excellent	Excellent	Good to fair	Excellent	Good	Excellent	Excellent	
-325	—	330–400	330–360	300–360	290–325	240–275	250–300	285–315	2
-3000	—	1000–3000	1000–3000	1000–3000	1500–6000	1500–2000	2000–2500	1500–5000	1
—	—	250–290	250–290	250–290	—	300–325	—	325–475	
—	—	300–5000	300–5000	300–50000	—	3000–30000	—	3000–30000	3
—	—	2.5–3.0	2.5–6.0	4.0–15.0	3	2.0	1.5–3.5	2	
—	—	0.005–0.009	0.002–0.006	0.0025–0.006	0.006–0.011	0.001	0.000	0.002–0.003	0.
-1.65	1.27–1.32	1.3–1.4	1.6–2.0	1.3–1.4	1.45–1.50	1.34–1.36	1.35–2.5	1.18	1
-16.8	21.8–20.0	21.3–19.8	17.3–13.9	21.3–19.8	19.1–18.5	20.7–20.4	20.5–11.1	23.3	2
	1.5–1.7	—	—	—	1.54–1.6	1.53	—	1.49	1
000	5000–12000	6000–11000	5000–10000	6500–8000	7000–10000	8000–10000	6000–12000	7000–9000	5
—	—	—	—	—	—	—	—	1–4	
—	8–15	10–25	10–45	7–12	12–15	3.5–4.1	3.5–8.5	6	4
-40000	15000–30000	28000–36000	24000–36000	26000–30000	24000–35000	—	—	8000	130
000	—	8000–15000	8000–20000	10000–13000	10000–13000	10000–13000	7500–12000	14000–17000	65
—	0.1–1.5 I, N	0.08–0.32 C, N	0.08–0.48 C, N	1.6–3.1 C, N	0.12–0.16 I, N	0.3–0.6 I, N	0.1–0.7 I, N	0.25–0.5 C, N	0
—	30–45	35–40 (50 kg.)	44–46 (50 kg.)	30–35 (50 kg.)	48–54 (500 kg., 10 mm.)	15–25	15–25	18–20	
—	3–5	3.5–5	10–20	5–8	7.1	4.0	Varies	4.3–6.8	
—	0.3–0.4	0.3–0.4	0.3–0.4	0.3–0.4	—	0.24	Varies	0.45	
2	2.8	3	2	4.5	1.5	6.9	Varies	8.5	
0–500	160	280–450	350–500	280–350	160	—	—	—	
one	—	Chars 450	Chars 550	Chars 400	None	130–160	130–160	170–235	1
—	—	268–288	277–297	—	260	140–150	140–158	158	1
one	—	None	None	None	None	Slight	Slight	Slight	
—	10^{9}–10^{14}	10^{10}–10^{13}	10^{8}–10^{11}	10^{9}–10^{11}	$(2–2.8) \times 10^{13}$	$>10^{14}$	10^{11}	$>10^{15}$	1
90	300–450	400–600	200–500	200–500	650–720	650	—	500	5
—	5–10	—	—	—	6.6	—	—	4–5	
—	—	4–8	4.5–20	4.5–6	—	—	4.7	—	
—	5–7	6–7.5	5–18	5–7.5	6	4	4	3	
—	0.025–0.20	—	—	—	0.034	—	—	0.06–0.08	(
—	0.005–0.08	0.04–0.15	0.1–0.15	0.06–0.20	—	0.014	0.02–0.15	—	<
—	0.01–0.045	0.035–0.1	0.04–0.1	0.035–0.1	0.01–0.03	0.018	0.02–0.065	0.02–0.03	<(
0.5	0.01–0.5	0.2–0.6	0.01–0.15	0.8–1.4	1–2	0.05–0.15	0.2–4.0	0.3	
ox. nil	Very low	Very low	Nil	Nil	Very low	Nil	Nil	Slow	
al	Hardens slightly	←	←	←	←	Strength unaffected	None	Very slight	
←	Colors may fade	Light shades discolor		←	None	Darkens	Discolors	Very slight	Ye al
←	←	←	←	←	←	Resistant	Dependent on filler	None	
←	←	←	←	←	Decomposed or surface attacked	Resistant	Dependent on filler	Oxidizing acids attack surface	N
←	←	←	←	←	←	Resistant	Dependent on filler	None	
←	←	←	←	←	←	Resistant	Dependent on filler	Slight	N
←	None	←	←	←	←	Resists alcohols, aliphatic hydrocarbons, and oils. Soluble in ketones and esters; swells in aromatic hydrocarbons		Soluble in ketones, esters and aromatic hydrocarbons	So arom chl hyd
←	←	←	←	←	←	←	←	—	1
←	Excellent	Fair to good	←	←	Fair	Good	←	Excellent	Po s
←	Transparent translucent opaque	Opaque	←	←	Translucent opaque	Transparent translucent opaque	←	Transparent (90–92 % light transmission)	Tran tran op
←	Unlimited	Limited	←	←	Unlimited; pastel shades	Unlimited, pastels to black		Unlimited	←

TIES CHART - 1938

cturers of each type of plastic material. Differences in test procedures and sizes of test specimen
ular property. The manufacturers should always be consulted before making a choice of materia
h of these chemical types of plastics has been prepared and will be found in the Directory Sectio

ETHYL HACRY-ATE ESIN	STYRENE RESIN	SHELLAC COM-POUND	COLD MOLDED		RUBBER COMPOUNDS			CASEIN	Ethyl-cellulose	CELLULOSE COMPOUN Cellulose
			Non-Refractory (Organic)	Refractory (Inorganic)	Chlorinated Rubber	Modified Isomerized Rubber	Hard Rubber			Sheet
xcellent	Good	Good	Fair	Fair	Fair	Good	Fair	Poor	Excellent	Excellent
85–315	220–275	240	—	—	200–225	260–300	285–350	200–225	320–360	210–320
00–5000	1000–5000	1000–1200	4000–12000	4000–12000	2000–5000	1200–4000	1200–1800	2000–2500	1500–2500	500–5000
25–475	300–450	—	—	—	—	—	180–220	—	380–425	—
00–30000	3000–30000	—	—	—	—	—	2000–5000	—	3000–30000	—
2	2.0	—	2.5	3.5	2–3	3	[illegible]	—	2.2–2.5	—
02–0.003	0.002–0.005	0.002	0.000–0.022	0.000	—	0.000	—	—	0.004–0.007	Positive and injection positive 0.005–0.007
1.18	1.05–1.07	1.1–2.7	1.98–2.00	2.20	1.64	1.06	1.12–1.80	1.35	1.14	1.27–1.37
23.3	26.3–25.8	25.2–10.3	14.0–13.9	12.6	16.9	26.1	24.7–15.4	20.5	24.3	21.8–20.2
1.49	1.61–1.62	—	—	—	1.56	—	—	—	1.470	1.49–1.50
00–9000	5500–8500	900–2000	—	—	2700–5000	4300	4000–10000	7600	7000–9000	6000–11900
1–4	1.0	—	—	—	0.5–2.2	—	8–15	—	10–40	20–55
6	4.6–5.1	—	—	—	—	4.7	5.3	5.1–5.7	2–4	1–3
8000	13000–13500	—	6000–15000	16000	—	8500–11000	8000–12000	—	10000–12000	4000–16000
0–17000	6500–8000	—	5300–7500	6000	—	7000–9000	8000–15000	—	9000–10000	—
25–0.5 C, N	0.16–0.25 I, N	—	0.4 C	0.4 C	2.8 I, N	2.6–6.2 I, N	0.5 I	1.0 I	0.6–1.8 I, N	0.15–0.60 C, N
18–20	20–30	—	—	—	—	85–90 (Shore)	31	23	—	6–11 (10 kg.)
3–6.8	1.9	—	—	—	3.0	2.6–2.9	3.2	—	5.6	5.4–8.7
0.45	0.32	—	—	—	0.37	—	0.33	—	0.25–0.40	0.3–0.4
8.5	7–8	—	—	—	12–13	7–8	8.0	8	10–14	14–16
—	—	150–190	500	1300	—	—	—	—	140–180	140–180
70–235	190–250	150	—	—	175–230	165–220	150–190	200	210–265	140–230
158	150–190	—	—	—	140	167–221	—	—	130–150	122–212
Slight	Slight	Slight	—	—	Slight	Slight	Slight	—	Slight	Slight
>10^{15}	10^{17}–10^{19}	—	1.3 × 10^{12}	—	2.5 × 10^{13}	(5–7) × 10^{16}	10^{12}–10^{16}	—	10^{15}	(5–30) × 10^{13}
500	500–700	100–400	85	—	2300	—	250–900	400–700	1500	800–2500
4–5	2.6	—	15.0	—	3	2.7	2.8	—	—	3.5–7.5
—	2.6	—	—	—	3	2.68	2.8–3.4	—	2.5–3.5	3.5–7.0
3	2.6	—	6.0	—	—	—	3	6.15–6.8	2.0–3.0	3.0–5.0
06–0.08	0.0003	—	0.20	—	0.003	0.006	—	—	—	0.02–0.07
—	<0.0001	—	—	—	—	—	—	—	0.005–0.025	—
02–0.03	<0.0001	—	0.07	—	0.006	0.002	0.003–0.008	0.052	0.007–0.03	0.04–0.09
0.3	0.00	—	1.5	0.5–15	0.1–0.3	0.02	0.02	3–7	1.25 (48 hrs.)	1.5–3.0
Slow	Slow	High (wood filler)	Nil	Nil	Nil	Slow	Medium	Very low	Slow	Slow
y slight	←	—	—	—	Slight embrittlement	None	←	Hardens slightly	Slight	←
y slight	Yellows slightly	None	—	—	Darkens	Slight surface crazing	Discolors; surface resistivity decreases	Colors may fade	Slight	←
None	←	Deteriorates	Slight	Decomposes	Resistant	←	←	←	Slight	←
lizing attack rface	None	Deteriorates	Decomposes	←	Resistant	←	Attacked by oxidizing acids	Decomposes	←	←
one	←	Deteriorates	Decomposes	None	Resistant	←	←	Softens	None	Slight
ight	None	Deteriorates	Decomposes	None	Resistant	←	←	Decomposes	None	Decomposes
n ketones, d aromatic carbons	Soluble in aromatic and chlorinated hydrocarbons	Attacked by some	←	None	Soluble in aromatic hydrocarbons	Attacked by some	←	Resistant	Widely soluble	Soluble in keton softened by alcoh little affected by
—	Inert	←	←	←	—	Inert	—	—	Inert	←
ellent	Poor to good	←	Poor	←	—	Good	Fair	Good	←	←
sparent % light nission)	Transparent translucent opaque	Opaque	←	←	Translucent opaque	Transparent	Opaque	Translucent opaque	Transparent translucent opaque	←
nited	←	Limited; pastels excluded	Dark colors only	Gray.	Unlimited	←	Limited	Unlimited	←	←

Additional co... Chart are avail... each. ...dress MODERN PLASTICS

st procedures and sizes of test specimens may lead to erroneous conclusions in
ulted before making a choice of material. In order to facilitate
nd will be found in the Directory Section

...s		CELLULOSE COMPOUNDS				
Hard Rubber	CASEIN	Ethyl-cellulose	Cellulose Acetate — Sheet	Cellulose Acetate — Molding	Cellulose Nitrate (Pyroxylin)	PROPERTIES
Fair	Poor	Excellent	Excellent	Excellent	Good	Molding Qualities
285–350	200–225	320–360	210–320	250–350	185–250	Compression Molding Temp., ° F.
1200–1800	2000–2500	1500–2500	500–5000	500–5000	2000–5000	Compression Molding Pressure, lbs. per sq. inch
180–220	—	380–425	—	300–440	—	Injection Molding Temp., ° F.
3000–5000	—	3000–30000	—	3000–30000	—	Injection Molding Pressure, lbs. per sq. inch
4–6	—	2.2–2.5	—	2–2.8	—	Compression Ratio
—	—	0.004–0.007	Positive and injection 0.002–0.003 Semi-positive 0.005–0.007 Flash 0.008–0.009		—	Mold Shrinkage, inches per inch
.12–1.80	1.35	1.14	1.27–1.37	1.27–1.63	1.35–1.60	Specific Gravity
24.7–15.4	20.5	24.3	21.8–20.2	21.8–17.0	20.5–17.3	Specific Volume, cubic inch per lb.
—	—	1.470	1.49–1.50	1.47–1.50	1.50	Refractive Index, N_D
000–10000	7600	7000–9000	6000–11000	3500–10000	5000–10000	Tensile Strength, lbs. per sq. inch
8–15	—	10–40	20–55	8–30	10–40	Elongation, %
5.3	5.1–5.7	2–4	1–3	2–4	2–4	Modulus of Elasticity, lbs. per sq. inch $\times 10^5$
000–12000	—	10000–12000	4000–16000	11000–16000	—	Compressive Strength, lbs. per sq. inch
000–15000	—	9000–10000	—	5200–8800	—	Flexural Strength, lbs. per sq. inch
0.5 I	1.0 I	0.6–1.8 I, N	0.15–0.60 C, N	0.60–1.1 C, N	0.25–1.0 C, N	Impact Strength, ft. lbs. C = Charpy, I = Izod, N = notched, U = unnotched
31	23	—	6–11 (10 kg.)	5–10 (10 kg.)	8–11 (10 kg.)	Hardness (2.5 mm. ball, 2.5 kg. load), Brinell No.
3.2	—	5.6	5.4–8.7	5.4–8.7	3.1–5.1	Thermal Conductivity, 10^{-4} cal. per sec. per sq. cm./1° C. per cm.
0.33	—	0.25–0.40	0.3–0.4	0.3–0.45	0.34–0.38	Specific Heat, cal. per ° C. per gram
8.0	8	10–14	14–16	14–16	12–16	Thermal Expansion, 10^{-5} per ° C.
—	—	140–180	140–180	140–180	ca. 140	Resistance to Heat, ° F. (continuous)
150–190	200	210–265	140–230	145–260	160–195	Softening Point, ° F.
—	—	130–150	122–212	122–212	—	Distortion under Heat, ° F.
Slight	—	Slight	Slight	Slight	—	Tendency to Cold Flow
10^{15}–10^{18}	—	10^{13}	(5–30) $\times 10^{13}$	(1–6) $\times 10^{12}$	(2–30) $\times 10^{10}$	Volume Resistivity, ohm.-cms. (50% relative humidity)
250–900	400–700	1500	800–2500	350–900	600–1200	Breakdown Voltage, 60 cycles, volts per mil (instantaneous)
2.8	—	—	3.5–7.5	4.5–6.2	6.7–7.3	Dielectric Constant, 60 cycles
2.8–3.4	—	2.5–3.5	3.5–7.0	4.5–6.0	—	Dielectric Constant, 10^3 cycles
3	6.15–6.8	2.0–3.0	3.0–5.0	4.0–5.0	6.15	Dielectric Constant, 10^6 cycles
—	—	—	0.02–0.07	0.01–0.04	0.06–0.15	Power Factor, 60 cycles
—	—	0.005–0.025	—	0.02–0.06	—	Power Factor, 10^3 cycles
.003–0.008	0.052	0.007–0.03	0.04–0.09	0.04–0.06	0.07–0.10	Power Factor, 10^6 cycles
0.02	3–7	1.25 (48 hrs.)	1.5–3.9	1.4–2.8	1.0–3.0	Water Absorption, immersion—24 hrs.
Medium	Very low	Slow	Slow	Slow	Very high	Burning Rate
←	Hardens slightly	Slight	←	←	Slight hardening	Effect of Age
...olors; sur-...e resistivity ...ecreases	Colors may fade	Slight	←	←	Discolors and becomes brittle	Effect of Sunlight
←	←	Slight	←	←	←	Effect of Weak Acids
...tacked by ...xidizing acids	Decomposes	←	←	←	←	Effect of Strong Acids
←	Softens	None	Slight	←	←	Effect of Weak Alkalies
←	Decomposes	None	Decomposes	←	←	Effect of Strong Alkalies
←	Resistant	Widely soluble	Soluble in ketones and esters; softened by alcohols; little affected by hydrocarbons		←	Effect of Organic Solvents
—	—	Inert	←	←	—	Effect on Metal Inserts
Fair	Good	←	←	←	←	Machining Qualities
Opaque	Translucent opaque	Transparent translucent opaque	←	←	←	Clarity
...imited	Unlimited	←	←	←	←	Color Possibilities

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PAGES 173 TO 258

MACHINERY AND EQUIPMENT

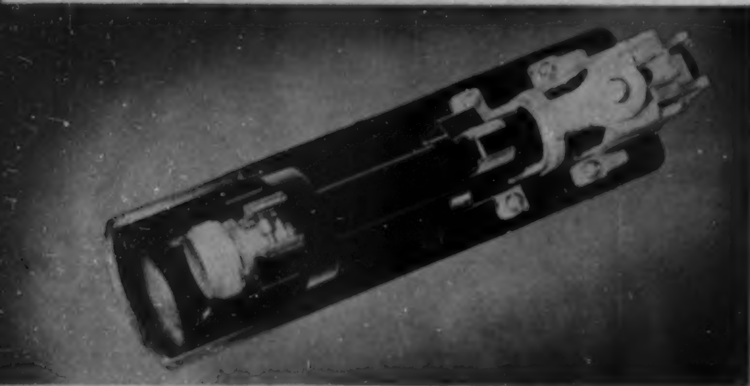
ASSEMBLY ACCESSORIES

EVER SINCE PLASTIC PARTS HAVE BEEN MOLDED in more than one piece, manufacturers have required some sort of fastening device for assembling various sections into a complete unit quickly and economically. Provision has to be made, too, for the mechanical attachment of the piece in service. This was particularly true in the electrical industry where plastics got their first start and consequently, heater plugs, electrical sockets, outlets, etc., were drilled and threaded so that mechanical contact parts could be screwed into place.

When it developed that plastics were capable of supporting metal inserts, which could be embedded into the part during the molding operation, new types of fastenings began to appear, until now there is available a wide and varied assortment to cover practically any function. Screws, bolts, studs or other metal accessories are securely anchored into place in the mold, the plastic material flowed around them and the part, after receiving the proper amount of heat and pressure, comes out with the metal inserts extending, all ready to be assembled. For instance, plastic handles may be molded with protruding screws so that the part can be attached easily to a drawer, stove, table or wherever it is to be used. The same is true of knobs for radios and the like.

An almost unbelievable accuracy in positioning is obtained and what is more, the inserts stay put. They can't work loose and fall out. This capability of accepting and retaining metal inserts has influenced the choice of plastic materials for certain rather difficult applications. Just as an example—actually, the one thing that makes the electric razor practical from the standpoint of cost is the fact that indispensable assembly inserts and bearings can be precision molded into the housing with threads of any specification or pitch already in place.

Of course, plastics can still be threaded and many of



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Speed in assembly is important to mass production; so is the permanence of fastening these devices provide. Fig. 1—Using thread cutting screws made by Shakeproof Lock Washer Co. Fig. 2—Parker-Kalon self-tapping screws attach the bearing head to the motor case in the Hoover Twenty-Five Cleaning Ensemble. Fig. 3—Bead Chain Mfg. Co. provides the permanent fastening for the cap on your Sparklets. Fig. 4—American Screw Co. makes these Phillips patented cross-slot screws which cling to the driver, leaving both hands free for the fastening operation

4

them are, but such threads are usually costly to build into the mold. Then, too, parts with threads molded into them must be unscrewed or jumped from the die. This operation requires extreme caution for if any of the threads are distorted, it is difficult to get the part to fit perfectly. For these reasons, this method is employed only where plastic parts are threaded to one another or to a mechanical thread for impermanent assembly.

When it comes to fastening parts together, ingenious devices have been worked out which have effected some economies over the drilling and threading method.

Self-tapping screws

This type of fastening requires a hole, without threads, which may be drilled or molded into the plastic part. As the screw is turned in, its hardened thread forms a corresponding thread in the material and no matter how many times it is removed and replaced, is not likely to strip its own threads nor those formed in the material. No special tools are required for these screws which are available in a wide range of sizes and head styles for assembling large or small parts. Among them is a screw with a hex head which speeds up the assembly operation to some extent because it can be inserted into the part with a power driven screw-driver.

Another thread cutting screw, designed especially for use with molded and laminated plastics, cuts a clean, sharp thread of standard size. Therefore, it may be replaced, if necessary, by a conventional screw of the same size without damaging the threads in the material.

Metallic drive screws

Where two plastic parts are to be joined together without any expectation of taking them apart or removing the fastening, metallic drive screws that grip permanently may be used. The drive screw, too, cuts its own thread as it is hammered into a drilled or molded hole of the proper size, or forced in with a press, singly or several at a time. An unthreaded section or pilot at the tip holds the screw in place and guides it straight into the hole. Since the diameter of the pilot is somewhat larger than the core diameter of the screw and slightly smaller than the outside diameter of the thread, the material is forced between the threads and the pilot, making a strong anchorage at the base and preventing the screw from backing out.

Recessed head, self-centering screws

The heads of these screws have a cross-cut tapered recess into which a tapered driver fits, so firmly that it cannot slip out. This construction is said to make possible less expensive, more solid and better appearing assemblies because:

1. These self-centering screws make it easy to reach awkward places since the driver can be pointed up or down and the screw won't fall out. The driver guides the screw, keeping it from going in crooked.
2. With the driver in place, the screw can be driven home with one hand, leaving the other hand free to hold the work.
3. Faster driving methods can be employed safely with no danger of scars, burrs and scratches caused by slipping screw-drivers.
4. The recess is strong, providing triple the purchase, of a slotted screw and since the driver stays in position more effort can be spent in turning and less in pushing.
5. These screws set up tighter, increasing the holding power against vibration. Consequently the number of screws required on each assembly can often be cut down, or smaller, lower cost sizes may become practical.
6. Fewer screws are broken or dropped on the floor and swept away with the waste.
7. The distinctive design of the recessed head screws, makes them particularly adaptable for use with decorative assemblies. They look well with heads in any position and where several screws are used on one part, a quarter turn will line them up, if desired.

Ordinary screw-drivers can be used for inserting these fastenings, but special drivers and bits are being made and distributed which exactly fit the recessed heads of these screws. Four driver sizes fit the entire range of screw sizes and two driver (*Please turn to page 254*)

Speed nuts and speed clips, made by Tinnerman Stove & Range Co. permit economical and rapid assembly. Fig. 5 shows a speed nut assembly of the plastic parts of automobile instrument panels. Fig. 6 shows the speed clip snapped over the slotted hub of a radio dial pointer

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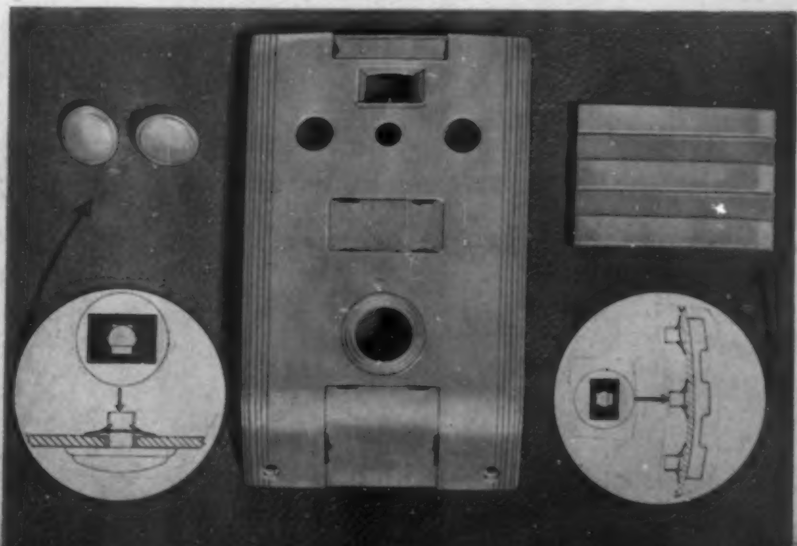

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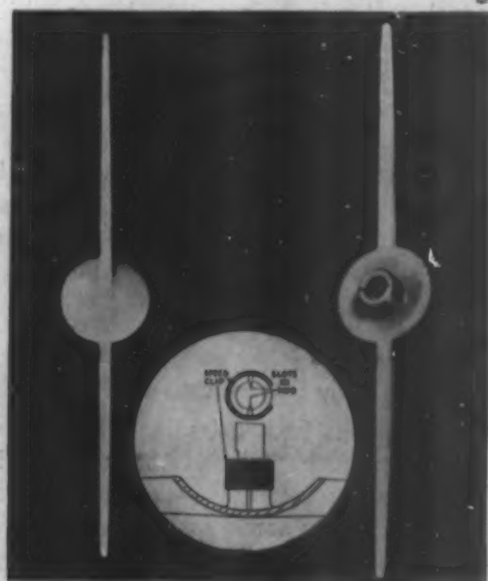

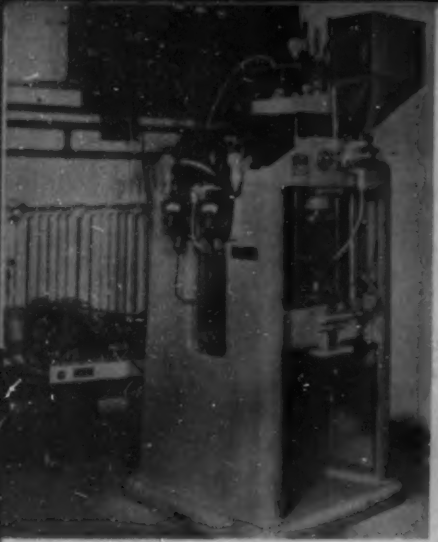

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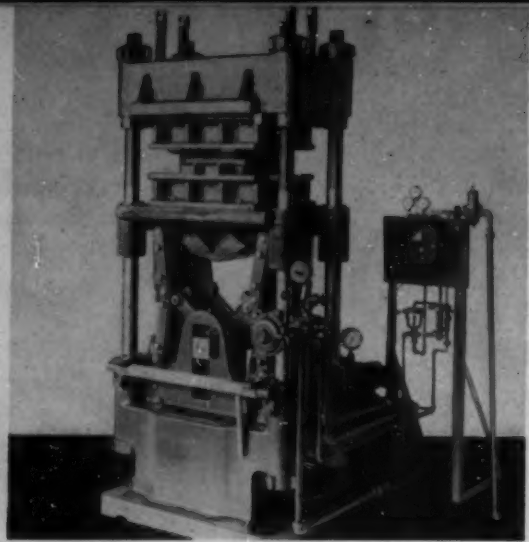

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Fig. 1—Fully automatic, self-contained molding machine for thermosetting plastics. Fig. 2—Semi-automatic, self-contained toggle-type press with time cycle control. (All photos courtesy F. J. Stokes Machine Co.)

AUTOMATIC MOLDING EQUIPMENT

by CHARLES J. WESTIN

THERE ONCE WAS A HAPPY PERIOD IN THE plastics industry when moldings had little or no competition. They were new and had quickly "caught on." Molders were few in number. Moldings were so superior in many respects to parts turned, die cast, stamped or otherwise produced from metal—and savings were so great—that there was profitable business for all. Equipment used had been "adapted" for plastics molding from metal working and mechanical rubber goods fields. There was little need or incentive to seek or develop cost cutting methods or equipment.

Today conditions are quite different. Moldings compete with moldings, not with metals. The smaller custom molder, with low overhead, competes with the larger molder who must offset his higher overhead with more efficient methods and equipment. And both small and large custom molders now have another competitor in the manufacturer of electrical specialties, toys and novelties, hardware, etc., who has found it profitable to set up his own molding plant to produce items in the quantities he requires.

In order to meet competition, expand markets for plastics and maintain satisfactory profits it is evident that corners must be cut, production increased, labor more effectively employed, uniform quality of moldings controlled, waste eliminated and costs reduced. To meet these conditions all the combined ingenuity of press builders, plastics materials manufacturers and molders is being brought to bear.

The completely automatic machine

So far as is known by the writer there is but one general purpose, fully automatic molding press for thermosetting materials. This press operates without attention and in actual installations has run more than 240 hours continuously, producing a finished molding every 70 seconds. Moldings produced in this manner are identical and the advantage of breathing is used to the fullest extent. Several dozen or more of these machines can be run by a single operator, who has nothing to do until a warning bell or light tells him a hopper is empty or, possibly that a piece is stuck somewhere on its way to the operation controls.

Single machines of this type in plants of custom molders also should be ideal for advanced study of mold design for big jobs and in the selection of the most suitable molding compounds. Since inexpensive, quickly made, single-cavity molds are used in this machine the molder can get quickly into production of samples, and can continue the machine in operation to meet early deliveries before multiple-cavity dies can be completed. Each machine is completely self-contained and electrically-heated, requiring only connections to electric wiring and air supply (for ejecting and cleaning)—no expensive steam auxiliaries are necessary. Any employee working near the machine can keep it supplied with powder, and at the same time assemble parts or do other routine work. This machine has been adapted for thermoplastics requiring heating and cooling. Again each operation of the cycle is exactly timed and controlled.

A complete molding plant

In Fig. 1 is shown a fully automatic molding press which, taken together with the small compressor standing at its rear, constitutes a complete self-contained molding plant. This machine automatically measures out and charges the mold cavity with the required amount of molding powder, closes the mold and holds it closed for the time needed to plasticize the powder, opens the mold only as far as may be *(Please turn to page 248)*

FINISHING PLASTIC PIECES

by R. H. GORANSON

IN THE PLASTICS INDUSTRY, THE TERM "FINishing" is broadly used to cover those operations subsequent to or supplementing the actual molding or fabricating process. Therefore, a discussion of this kind cannot properly be limited simply to polishing and buffing; such operations as filing, drilling, tapping, sanding, cleaning, tumbling, gaging, and inspecting are all so closely related under the head of "finishing" that they must also be dealt with.

Some molded parts, except for the removal of the flash or fin, require no other finish than that imparted to them by the mold. The vast majority, however, require several subsequent operations before they can become completed pieces. For these subsequent operations, the molder has adapted to his use, the experience, methods, and equipment employed by both the metal and woodworking industries, but with such changes and improvements as are necessary to meet the conditions peculiar to plastic materials.

After a casting has been taken from the mold, the first step is what is known as "rough finishing"—that is the removal of the flash from the parting line, and from any openings in the part. Next, usually, will follow any drilling and tapping operations which may be necessary; then whatever buffing may be needed to produce the desired quality and luster of finish.

Inspection, as a rule, is a more or less continuous process, occurring at each individual step from the time the piece leaves the mold, until it is completed. From the standpoint of economy, it is far better to discard a defective piece as soon as the defect occurs, than to waste additional operations on it.

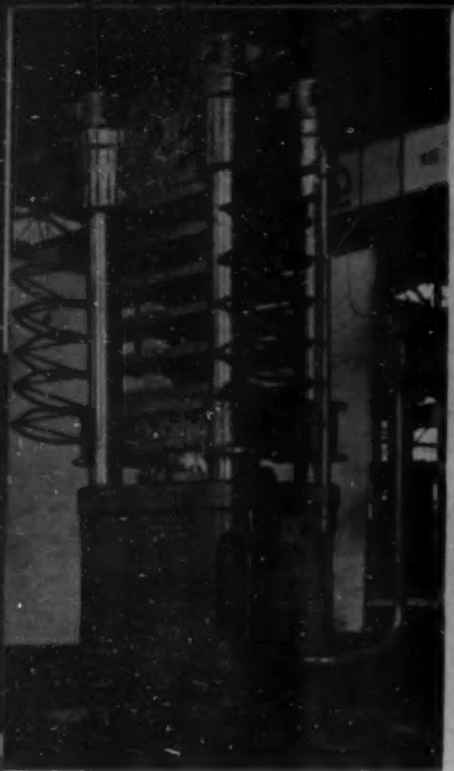
Although the finishing process proper begins when the piece leaves the mold, nevertheless, the mold itself plays an important part in the finish imparted to the piece. Steel plates are used to give the piece a dull finish and the higher the polish of the mold, the greater the degree of luster imparted to the piece. Where extremely high luster is required, plates of highly polished chromium or stainless steel are used.

Since highly polished molds are expensive, the degree of finish in the mold will often depend on the number of pieces to be produced from it. If the number of pieces is to be relatively small, it is usually most economical to impart the desired degree of finish to the parts after molding. On the other hand, if the run is to be large, the higher cost of the polished mold will be more than justified by the saving in subsequent handling.

When the group of identical parts are received from the molding press, and have been carefully checked for imperfections, the first step is the removal of the flash or fin which occurs where the mold separates.

If the pieces are fairly large ones, best results can be obtained usually by the use of a horizontal belt sander. This is particularly true if there are flat surfaces to be finished. If, however, the part is irregularly shaped, it may be advisable to use a flexible shaft grinder equipped with an abrasive polishing (*Please turn to page 244*)

Muslin wheels mounted on a lathe spindle are used for polishing, and felt wheels for bringing out luster (left). Flash in difficult spots is removed by filing (right). (Photos courtesy Chicago Molded Products Corp.)



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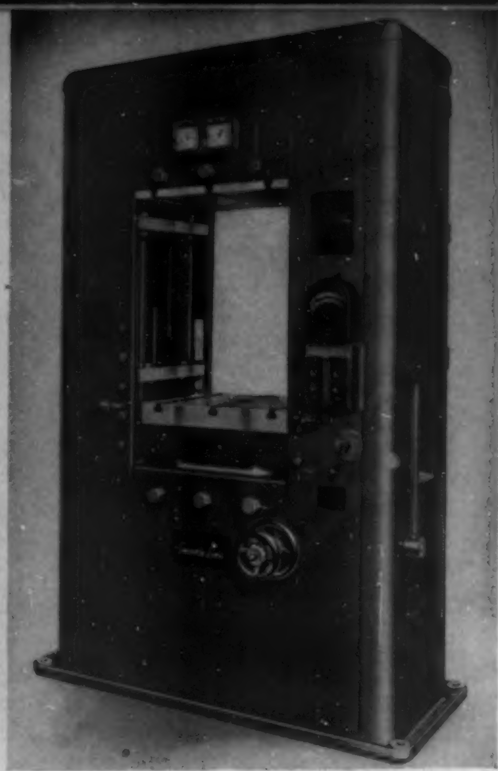

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Three examples of modern presses illustrating the wide range of equipment available for fabricating plastics. Fig. 1—A towering laminating press to turn out large-area laminate sheets and panels. Fig. 2—Two fully self-contained plain steam platen presses which may be installed regardless of pressure lines location. (Photos courtesy Baldwin-Southwark Corp.) Fig. 3—A larger type of self-contained press. This semi-automatic machine is equipped with automatic heat and pressure controls. (Photo courtesy Hydraulic Press Mfg. Co.)

HYDRAULIC COMPRESSION PRESSES

by GEORGE F. SULLIVAN

MR. BROWN'S LETTER TOLD US THAT HIS COMpany needed equipment for plastic molding but stated frankly that they were not familiar with the set-up required. When he called at the office he had with him a sheaf of blueprints and a few plaster-cast models of some of the pieces they proposed to make. On our desk was a blank production chart.

His job, he explained, was to investigate the compression molding end of their proposed plant. "We would like to figure," he added, "on an 8 hour day, 200 hours per month."

He pulled out the blueprints of piece No. 1. It had a complicated contour resembling a flatiron handle. Five thousand pieces a year were required. The mold would have to be made in sections and taken apart to get the pieces out. Tentatively we suggested using a 2-cavity mold in a 30-ton press. The press could have either steam or electrically heated platens. When the piece was cured the mold would be slid out of the press and opened in an arbor press.

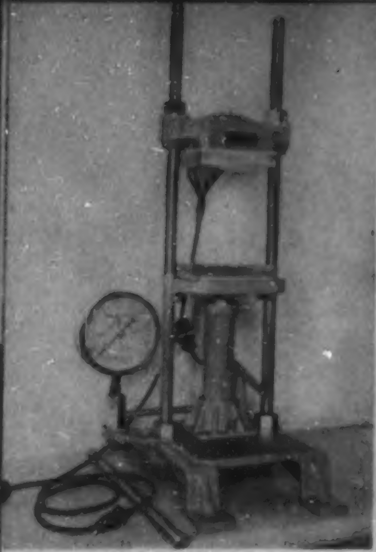
"But," said Brown, "I thought hand molding was old-fashioned."

"In a way it is," we replied, "but it is still the most economical way to make pieces that require a complicated, and therefore expensive, mold—particularly where high production is not called for. We'll probably find more pieces which you don't require in quantities great enough to justify a semi-automatic mold and press. Piece No. 4, for instance, is a tube with an external thread and a fairly thick wall section. Since you need only 5000 a year, hand molding seems advisable."

Filling in our production chart we found that one 50-ton plain platen press would be sufficient for pieces Nos. 1 to 8. But since Brown also wanted a small unit for experimental work we included a 30-ton press of the same type, which could be used to step up production. It would be fitted with a hand pump which would be bypassed when the press was used in production work.

"We can't afford an operator for each of those presses," wailed Brown.

"One operator," we replied, "can handle both presses. In fact, unless you plan to have your operators do some finishing work, one operator can generally handle any two presses. Where semi-automatic presses are used the operators can be girls, provided the molds aren't so large that they require heavy filling (*Please turn to page 240*)



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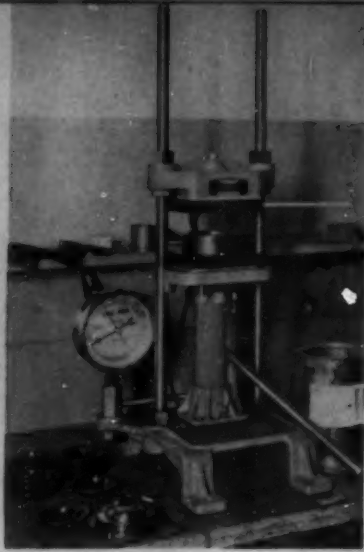

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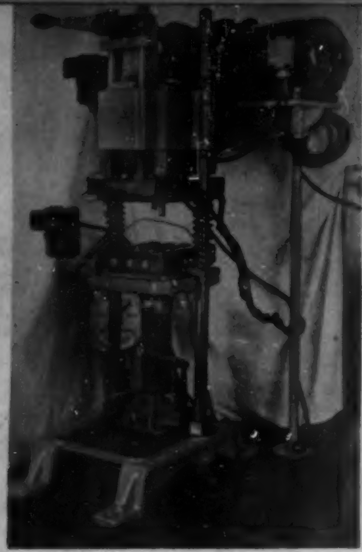

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Here are three views of the Carver laboratory press. Fig. 1—The press showing electrically heated platens; Fig. 2—A molding plant in miniature; Fig. 3—Fitted with a special head for molding closures

LABORATORY PRESSES

by FRED S. CARVER

THE PROGRESS OF AN INDUSTRY IS GENERALLY geared to its laboratories, and plastics is no exception. Rather, due to the youth of this modern industry, it must of necessity spend a great deal of its time and energies in laboratory work. This laboratory time may be divided into three phases: (1) research, (2) development and control and (3) the production of sample pieces.

After the research chemist has apparently discovered a new plastic or believes that he has effected an improvement in an existing material it must be subjected to countless tests; first, to determine whether the material has possibilities, and second, to lay down the proper procedure for fabricating it.

The first step involves the fabrication of test pieces. If the compound is intended to be moldable the research man will probably select a press fitted with electrically heated platens similar to that shown in Fig. 1. He will place a small mold in this press and turn out some experimental pieces. The same press, with its plates cold, will then be used for crushing and compression tests on these pieces. Flow tests will also be run, for if the material is too stiff it will have to be altered. If he is working on lamination the same equipment becomes a miniature platen press to produce laminated samples for further test. Similarly, if the field is extrusion this equipment may be fitted in between the platens or a special extrusion head may be used.

If he is satisfied with his progress, the research man may now turn the molding material over to the development and control staff. Their problem is to study the behavior of this material under various conditions of temperature and pressure. Equipped with an accurate thermostatic control, the press illustrated in Fig. 1 will be used for these experiments. With the press cold, standard test cylinders may then be used to determine whether or not the material can be preformed, and, if so, the pressure required. If tests are to be run on a thermoplastic material it must, of course, be cooled under pressure. This work merely calls for the substitution of steam for electric plates so that cooling water may be run through the channels of the platens.

To many a layman, a laboratory is merely a place where inventions are born and new processes developed. Its importance in the development and control of existing processes is often overlooked. This is especially true in the plastics industry where the saying that "no two problems are alike" is not without foundation.

If there is an intricate multiple cavity mold to be built, time and money may often be saved by first constructing a single cavity experimental mold. If this is placed in a laboratory press, where frictional loss in the ram is reduced to a minimum, the ideal molding pressure per square inch on the cavity may be accurately determined. In this way there will be no possibility of planning a mold for a given press and then discovering that the press has insufficient power to fill out all the cavities. At this stage, too, it will obviously be less costly to make any changes in mold design. Will the piece adhere to the top or the bottom half of the mold? Will it fill out properly or is a slight change indicated? How long will it take to cure? All these are questions that the experimental mold can answer swiftly and inexpensively.

Further, if it appears that unusual power will be required to open the mold this factor will have to be obtained in advance. With the proper flanges on the experimental mold this figure can readily be secured by blocking it up and reading the gage. The single cavity mold need not be discarded when the multiple cavity equipment is built. For as the manufacturers bring out new materials they can be tried out without interfering with the production mold. The molding superintendent generally hesitates to interrupt (*Please turn to page 258*)

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MODERN PLANT EQUIPMENT

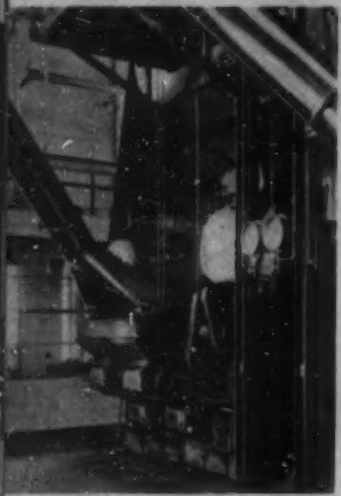

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Fig. 1—The first element of a complete thermal system—an automatic stoker installation. (Photo courtesy Hoffman Combustion Eng. Corp.) Fig. 2—A bend provides for expansion in an insulated steam line. (Photo courtesy Power Piping Division, Blaw Knox Co.) Fig. 3—A Supertherm high pressure hot water pump at Synthane. (Photo courtesy J. O. Ross Eng. Corp.) Fig. 4—Air compressors, accumulators and hydraulic pumps in a modern plant. (Photo courtesy Power Piping Division Blaw Knox Co.)

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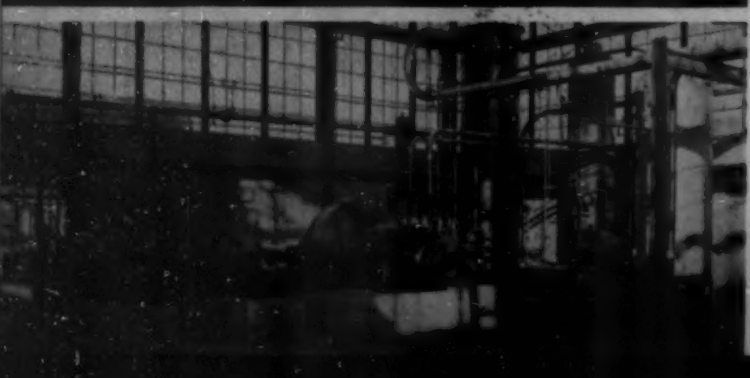

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SAYING "IT CAN'T BE DONE IN PLASTICS" TO the average molder today is like wearing a bright red shirt through a pasture inhabited by a bull—it gets immediate action. The part in question may be intricate or oversize; it may be subject to changes in temperature, hard usage or any one of a dozen other specifications. But the molder will wear out many a pencil, heckle his engineers and designers until they haven't an answer left, before admitting under his breath that perhaps it wouldn't be practical. For no sooner does he reach this decision than he is likely to hear of a brother molder in a different section of the country who has accomplished what he considers the impossible.

Right then is the time to check up on methods and equipment. The shop that clings to antiquated molding practices and obsolete machinery cannot hope to compete in quantity and quality of production with those equipped with modern, up-to-the-minute apparatus. This past year has seen the establishment of several new molding shops and extensive additions to old ones, and in each instance, the latest in improved accessories have been installed.

What does it take to adequately equip a modern molding plant? Whether the shop is large or small, whatever type of plastic merchandise is to be produced, there are certain fundamental necessities that must be included. Let us consider in detail the nature of these.

Power plant

The foremost requirements in molding any plastic part are heat and pressure—heat enough to plasticize the material and pressure enough to flow the softened mass over the surface and into every corner of the mold. Steam is the medium most generally used for heating platens or molds although some smaller plants find it convenient to use gas or electricity. A few more recent installations employ hot water for this purpose. Pressure is applied by hydraulic or mechanical molding presses (described elsewhere in this issue).

Heat supply. Where a series of presses are to be serviced, a centrally located boiler unit generates steam which may be controlled as required at each press by means of a steam reducing valve. As heat is drawn into a press, some steam condenses and this moisture is drained or removed from the platen and mold through individual steam traps and returned to the boiler.

The size or capacity of the boiler is determined by the number of presses installed and since an unlimited and continuous supply of heat is absolutely essential for uninterrupted operation, the choice of boiler becomes an important consideration.

"The trend in general," we are told, "has been to take the boilers out of the fire, and to build them around the fire, thus making use of as much radiant heat absorption

Fig. 5—Preforms and powder are preheated in this eight-drawer oven adaptable to either gas or electricity. (Photo courtesy Despatch Oven Co.) Fig. 6—An electric vibrator attached to the dies on a preform press helps settle the material in the die. (Photo courtesy Syntron Co.) Fig. 7—Alnor temperature controller maintains even temperature on an injection molding press. (Photo courtesy Illinois Testing Laboratories, Inc.)

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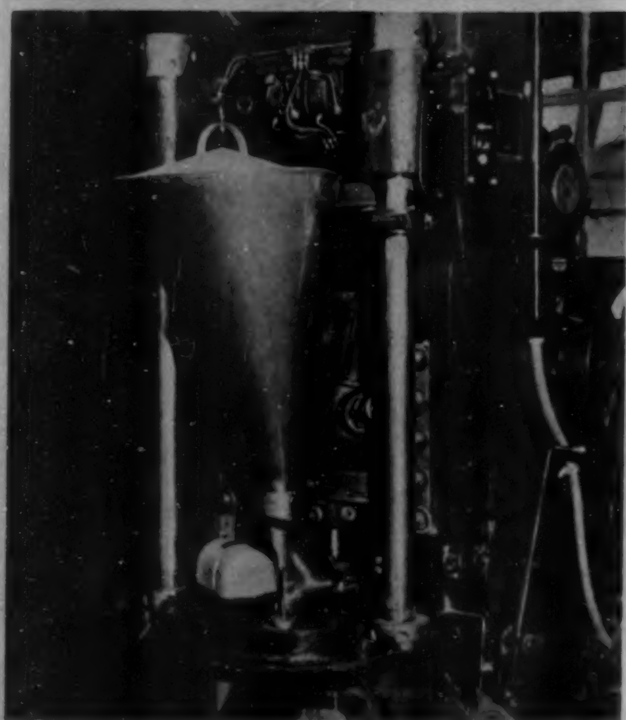

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as possible. This trend has brought the so-called water tube class of boiler into the foreground, and pushed the fire tube type into the background. The reason for the change has been purely the resultant higher efficiencies with very little maintenance cost. In other words, the actual cost of steam per pound has been lowered."

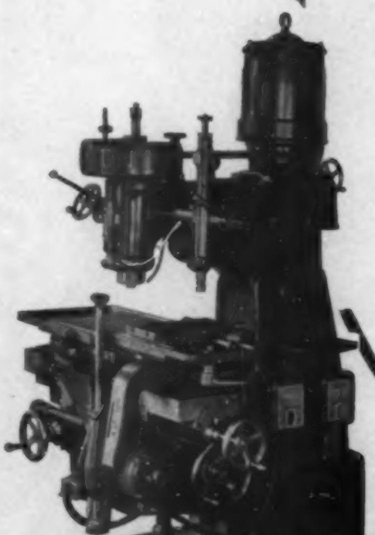
Mold heating by hot water is accomplished by the supertherm system. Water in the boilers is held at the same pressure and temperature as steam. Therefore, if the water is circulated at or above boiler pressure, the same temperature is available at the presses. Heat is extracted from the water, which slightly reduces its temperature; the water is then returned under full pressure in a closed system to the boiler. With this method, no traps are necessary at the presses and full recovery of unused heat is obtained.

Whatever the type of boiler, whether it burns coal or oil, a steady steam pressure at all times is best maintained through automatic firing. When the fuel used is coal, automatic stoker firing provides even, continuous steam pressure, low labor costs and clean stack conditions. A clean stack is essential because plastic materials will not permit any contamination from soot or other emissions from the power plant stack. In selecting automatic stoker equipment for economical steam production, the first step is to determine upon the most favorable coal supply from the standpoint of price, plus freight rate to the point of use. Then the stoker equipment chosen must be capable of operating efficiently with this coal in conjunction with the size and type of boiler used, at the steam load required.

Hydraulic pressure equipment. A considerable portion of the power plant space is devoted to hydraulic equipment which is the favored method of applying pressure to molds. A high pressure system alone may be used but ordinarily a dual high and low pressure system is preferred for more capable and economical operation. With this dual arrangement, the mold is partially closed at a low pressure of 250 to 500 lbs. per square inch and the plastic material is thoroughly heated and softened before the final closing of the mold at a high pressure of 2000 to 3000 lbs. per quare inch.

Both high and low pressure lines consist of accumulator and pump with the essential controls. Where a number of presses are operated, the accumulator provides pressure storage which is drawn upon as needed for even distribution along the line. There are several styles and sizes of these and the choice depends, among other things, upon the probable location of the accumulator in the shop and the number of presses installed. One type of weighted accumulator has a vertical ram loaded with cast iron or concrete blocks so arranged that one or more can be removed to give different operating pressures. In another, the loading material—iron ore, steel punchings, pig or scrap iron, etc.—is contained in a tank. Both of these are extremely heavy and must be installed on a solid and substantial foundation. Oftentimes such accumulators are sunk below the level of the floor to make room above them for practical operation.

A more recent addition to the accumulator family is a



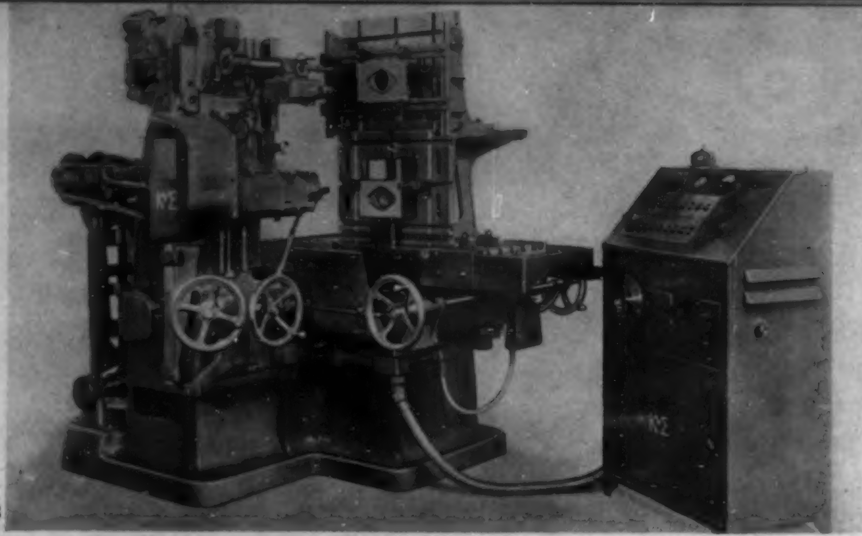


Fig. 8—Particularly suited to produce molds of irregular shape, the Keller Automatic Tool Room machine may be used either for automatic profiling or full automatic operation. The precision locating attachment permits the spindle to be located accurately

compressed air ballast type, made up of huge, steel bottle-like containers. These are charged with air and then filled with liquid up to the required working pressure. By making the volume of air in the container greater than the volume of liquid, possible variation of hydraulic pressure over the entire line is reduced to a minimum. A hydro-pneumatic control, operated by the accumulator pressure, consists of two cylinders. One of these regulates the level of the pressure fluid in the bottle by automatically by-passing the pump when the accumulator is charged to capacity, and admitting new pressure fluid from the pump after withdrawal of a certain amount of liquid. The second cylinder controls a stop valve, automatically stopping withdrawal of liquid from the bottle at the lowest possible liquid level, preventing compressed air from entering the system. The air ballast accumulator, unlike its weighted brother, requires no extra heavy foundations for installation.

Each hydraulic line is served with a suitable pump which forces liquid into the accumulator in sufficient quantities to maintain proper pressure for the number of presses in operation. Belt or motor driven reciprocating pumps of two, three and four plungers are commonly used to furnish high pressure liquid, the low pressure line usually being operated by a centrifugal pump. In some shops steam driven pumps economically provide both high and low pressure liquid. Hand pumps are also used to some extent but only in connection with hand molding presses. The pumps may be horizontal or vertical, whichever fits best into the section provided for it.

Hydraulic pressure is regulated at each press unit by manually or automatically operated control valves. There are many different kinds of control valves and each molder has his own opinion as to the best one to use. However, automatically operated valves are generally conceded to be more accurate, and more saving of time and labor. A typical automatic two-pressure valve is connected to the low pressure, high pressure and exhaust lines. The valve plug is turned by a hydraulic cylinder operating through a rack and pinion and this cylinder, in turn, is actuated by a pilot valve connected with the low pressure line. A lever and latch moves the plunger of the pilot valve as the motor driven timing device rotates. A notch on the timing wheel coincides with the prescribed timing interval (*Please turn to page 228*)

Fig. 9—This three-spindle duplicator is shown producing small cores from sheet metal templates. This type machine permits simultaneous reproduction of three jobs. Fig. 10—The twelve-impression mold shown on the Keller Die-sinker machine was turned out in thirty-six hours. (Photos courtesy Pratt & Whitney)

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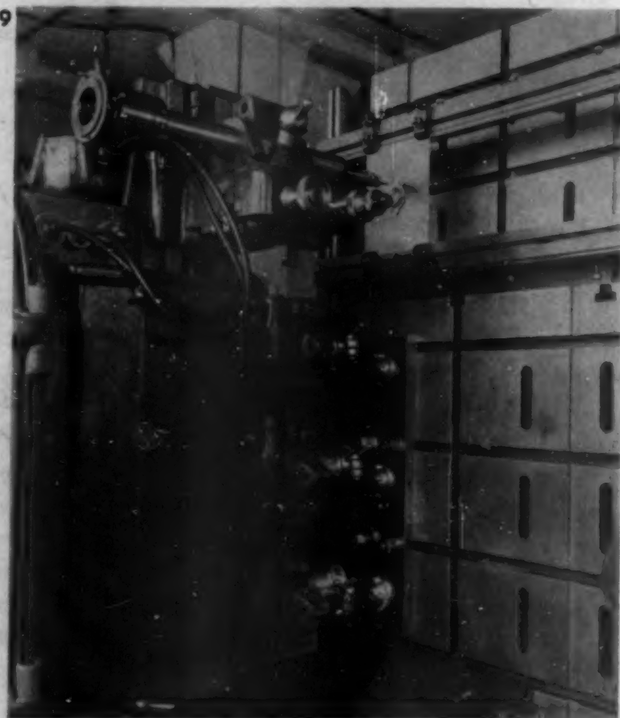

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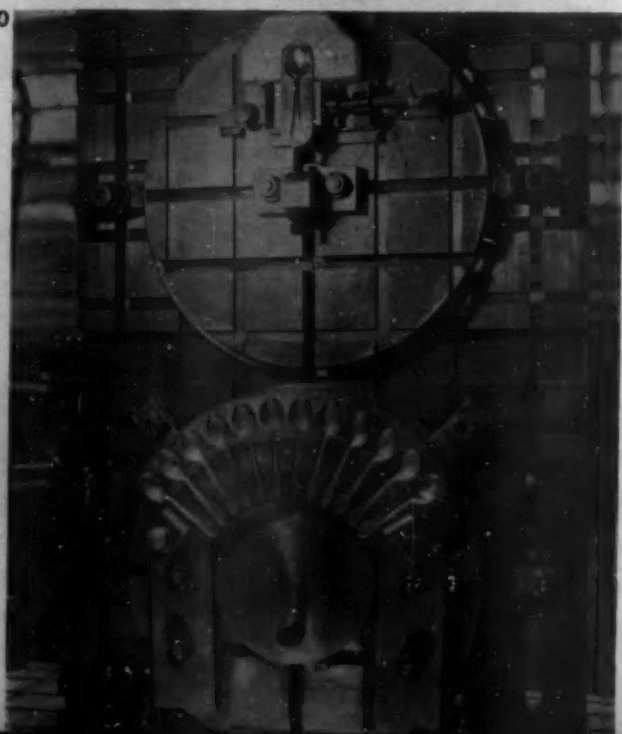


MOLD DESIGN AND CONSTRUCTION

by E. F. BORRO

ASSUME THAT WE HAVE ESTIMATED ON A phenolic part, and that the estimates were based on a multiple cavity semi-automatic mold. Some time has lapsed before this order has been placed, and by this time the engineering and production departments have practically forgotten about this estimate. They are not expected to remember these things because of their numerous duties in their regularly assigned posts.

Upon receipt of the order, immediate conference is called between the Engineering, Estimating and Production Departments in order to refresh their memories and review records and estimate sheets, and at this time definitely decide upon the type of mold and number of cavities, as it might be advantageous to change the number of cavities in order to simplify mold construction, or reduce the cost of production. Also by this time the right type of phenolic material has been selected.

Since the shrinkage of phenolic materials varies from .003 in. to .010 in. per in., it is very important at this time to check the material manufacturer's data for shrinkage on this particular material. It has often been taken for granted that .008 in. shrinkage per in. will be allowed and when the mold was completed it was discovered that the material that was going to be used had a shrinkage of .004 in. per inch. Incidents like this do not happen when there is sufficient information on the drawing, and proper cooperation with the mold maker.

Upon reaching such decisions, the Engineering Department proceeds with the drawings. Decisions must be made on a few important facts; some of them seem inconsequential although they often prove to be expensive if no consideration is given while making the drawing. Here are a few of the things to be considered.

Guide or dowel pins should if at all possible be on the bottom of the mold. This prevents preforms, flash and dirt from falling into the guide pin holes. There have been many dollars spent on repairs of molds in the molding industry because the guide or dowel pins were on top of the mold.

Very often we see finished dimensions for thickness of chase or nest plates given as 3 inches. This of course requires a purchase of thicker steel to allow for finishing. In large sizes of plates, it is often impossible to purchase $3^1/_4$ in. thick plates. It is necessary to use $3^1/_2$ in. plates, and machine them to 3 inches. In cases like this the molder is paying for $^1/_2$ in. of steel and he is also paying for machining and throwing it away. In most instances this chase or nest plate could be $2^7/_8$ in. and 3 in. plates can be used, allowing $^1/_8$ in. for finishing. The same applies to molds where separate steam plates are required; if $1^3/_8$ in. thickness is specified, $1^1/_2$ in. plate steel can be used.

The selection of steel for nest plates is important. A .10 to .15 low carbon machine steel will simplify the machining and definitely reduce mold costs. However, much difficulty can be encountered, especially on long production jobs, due to the spreading of chase plates and sinking of cavities. These consequently cause misalignment of cavities and non-uniformity of fin thickness, producing ultimately pieces that are not to *B/P* dimensions. When .35 to .45 carbon steel is specified, the uncertainty of mold alignment during long production is reduced to the minimum. Fig. 1 illustrates that in some instances where low carbon steel is used for chase plates, it is necessary to use a high carbon backing plate to prevent cavities from sinking. Inasmuch as this method might prevent the cavities from sinking, it is done at a sacrifice of heat conductivity. The cost of this method is undoubtedly equal to that of using high carbon steel for the entire chase plate.

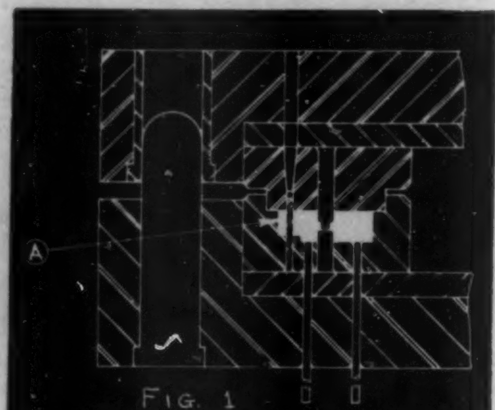
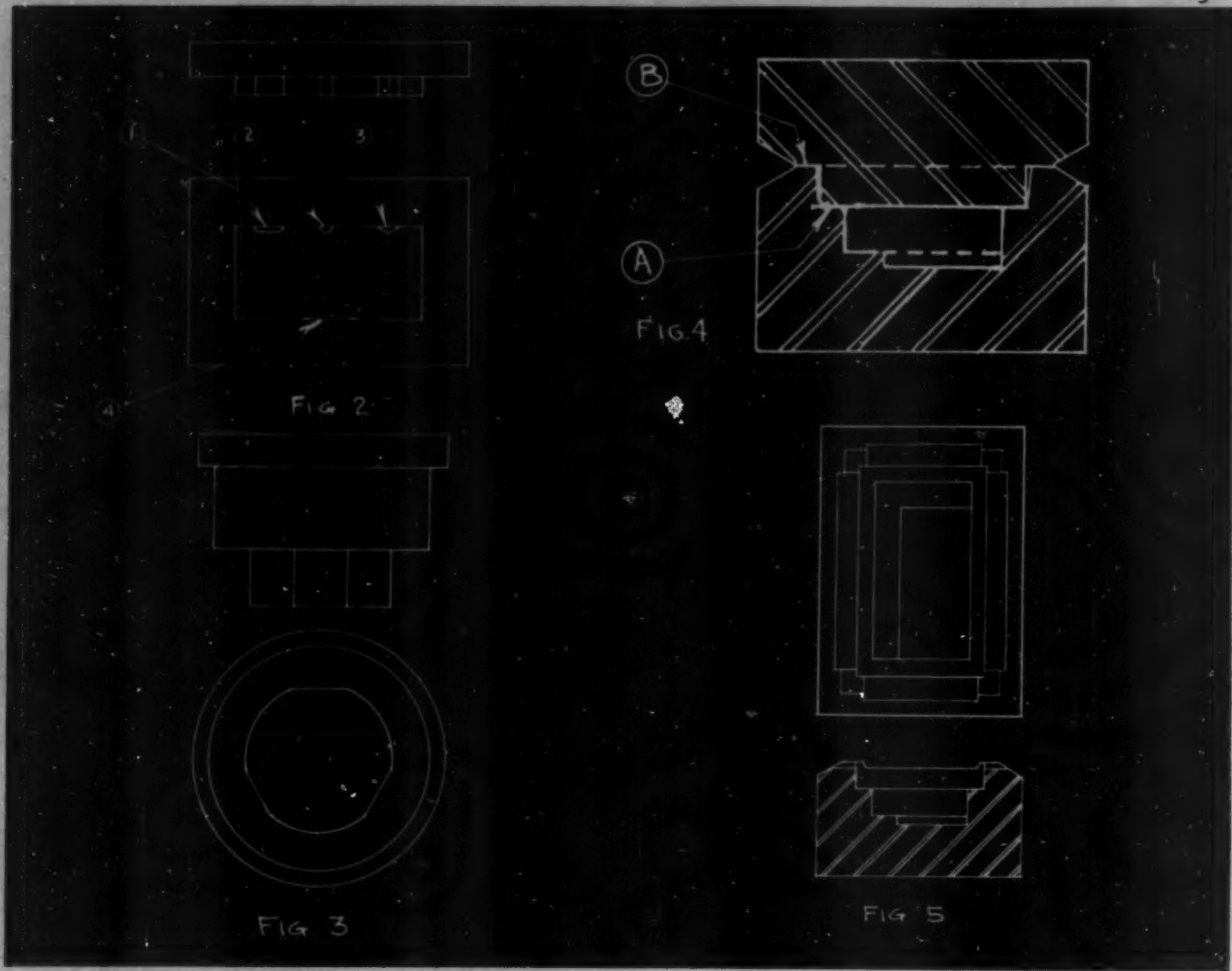


FIG. 1

Looking ahead

To obtain uniformity of heat distribution it is necessary to lay out the steam channels as accurately and uniformly as possible. Frequently when black and brown orders are exhausted, color materials are used as business stimulant and uniform temperatures are important.

Moreover it is usually found that while chilling was not included in the estimate, it is often adopted after the mold has been tried in production. If proper consideration is given to the steam channel layout, in most instances, the total chilling and curing time does not exceed the curing time of an improper steam channel layout. It is essential to space or block off the cores for proper complete steam circulation. A 20 in. by 18 in. mold



that was not spaced for steam channel circulation was recently in production, and upon checking the temperatures it was found that there was a difference of 20 deg. F. between two corners of this mold. Of course this great difference in temperature, even on black phenolic, was producing pieces of two qualities. Some pieces were very brilliant and some had a dull finish.

Grooving for cleaning

Molding holes or slots from top and bottom and maintaining alignment requires close fit between force plug and cavity. On positive or land-type positive molds, it is necessary to provide sprue or escapement grooves. Mold operators would appreciate a mold with sprue grooves so that a shot of air would clean out the flash without poking with the point of the air nozzle, or brass chipping tool. Plant owners would show a remarkable saving in labor cost and percentage of rejects. It is evident that when the sprue grooves are not cleaned out and flash remains for the next shot, the surplus material cannot escape. Consequently, it is bound to produce some light pieces in a multiple cavity mold. Moreover, it does not do the mold any good. The cavities that have the sprue left in are absorbing considerably more pressure than the cavities with the sprue grooves open, allowing the surplus molding material to escape freely.

Fig. 2 illustrates sprue grooves, numbers 1, 2 and 3 which are often used, but are very difficult to clean. Fig. 4 illustrates a sprue groove that can be cleaned with a shot of air, because there are no possible chances of material sticking.

Fig. 3 illustrates a round force plug with flat escapements which are simple to machine and provide excellent sprue grooves. In most instances it does not require a shot of air to clean, because the flash falls off when the mold is opened.

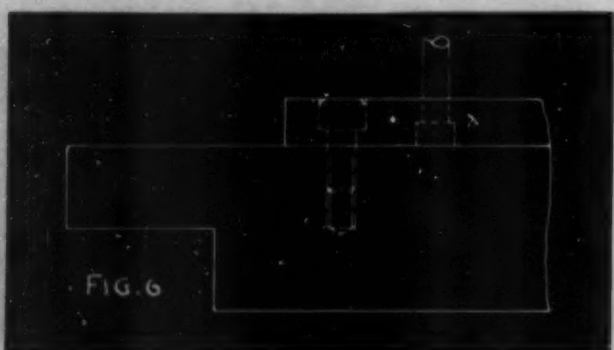
Even in this advanced plastics age we often see land-type positive molds landing at two points *A* and *B*, as illustrated in Fig. 4. Molds of this type are seldom successful because stiffer materials cannot be used. It is necessary to use softer flowing materials to have the surplus material flow pass the two locking points *A* and *B* and obtain a commercial fin at the cut-off *A*. When softer materials are used there is a sacrifice of curing time and also of surface quality. If a non-uniform charge of material is put into the cavities of this type of mold, it often results in cracked cavities. Needless to say, it makes the maintenance of such a mold expensive. If additional safety landing is required other than pressure pads on the mold chase, it has been found successful to machine

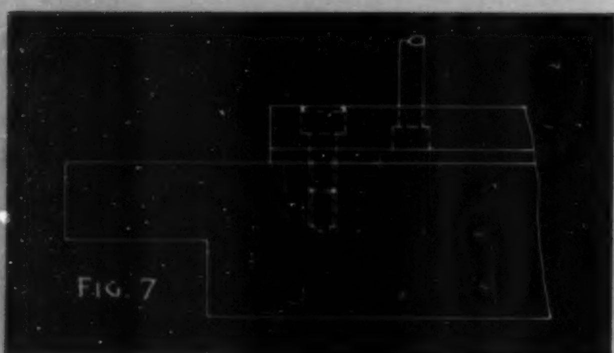
away the landing at the ends and sides, leaving the corners for additional landing as illustrated in Fig. 5.

Molding of small holes is indicated in Fig. 1, letter *A*. If the decision of pin construction is left to someone without the necessary molding experience, they will unquestionably take the way of least resistance and construct the mold so that the pin will butt up against the force plug, not realizing what difficulties the molder will be up against when the mold is put in production. Entering the pin into the force plug as shown in Fig. 1 obviously increases the mold cost. This extra cost is saved in a short time through fewer replacements of broken pins and elimination of piercing fins out of the hole.

Ejector pin construction

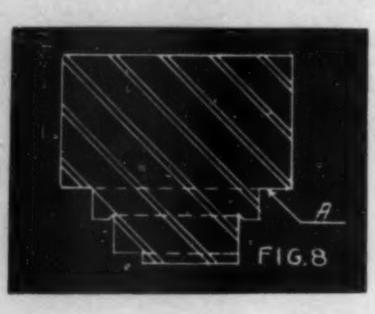
There are many types of ejector pins and bars construction, some of which present real difficulties, especially when the pins can move up and down. Often, when the ejector bar is returned, the pins that have the play remain up. Because of the friction and flash around the pin the pressure of material does not push it back and consequently it holds impressions instead of being flush with the surface of the molded piece. Fig. 6 illustrates an ejector bar of a simple construction which presents little difficulty. This type of pin head construction can easily be riveted on drill rod pins and machined to close dimensions. The retaining bar can also be counterbored to a close tolerance. In most instances standard cold rolled steel bar stock is used for ejector bars, and for some sizes of pins. The heads of the pins eventually sink into the soft ejector bar. This can be overcome by using a bar construction (Fig. 7) with a strip of 1/8 in. spring steel in between the bar and retaining bar. Spring steel possesses the right degree of toughness and the pins will not sink into the spring steel backing plate.





During the design of the mold, we should not entirely forget the preform or powder loaders, metal insert loaders and necessary stripping forks. On certain molds it is advantageous to provide slides for material or insert loaders in order to speed up and simplify this operation. When these are considered while the mold is being designed certain provisions can be made on the mold drawing. The construction of leaders is carried on at the same time with the mold, and necessary spotting and transferring of the cavities or holes onto the loader can be done before the final mold assembly.

At the completion of the drawings, the design should be reviewed by the production department's representative. If possible the assistant or shift foreman should be given an opportunity to express his opinion and make suggestions. These forgotten men in the Press Room often have splendid ideas but they cannot be presented until the mold is in production, when it is too late. By discussing the designs with these men we often obtain valuable suggestions. At the same time these men are broadening their knowledge of mold design and reading of drawings, and becoming more valuable to their employer. In due time they can fill more responsible positions in this rapidly growing industry.



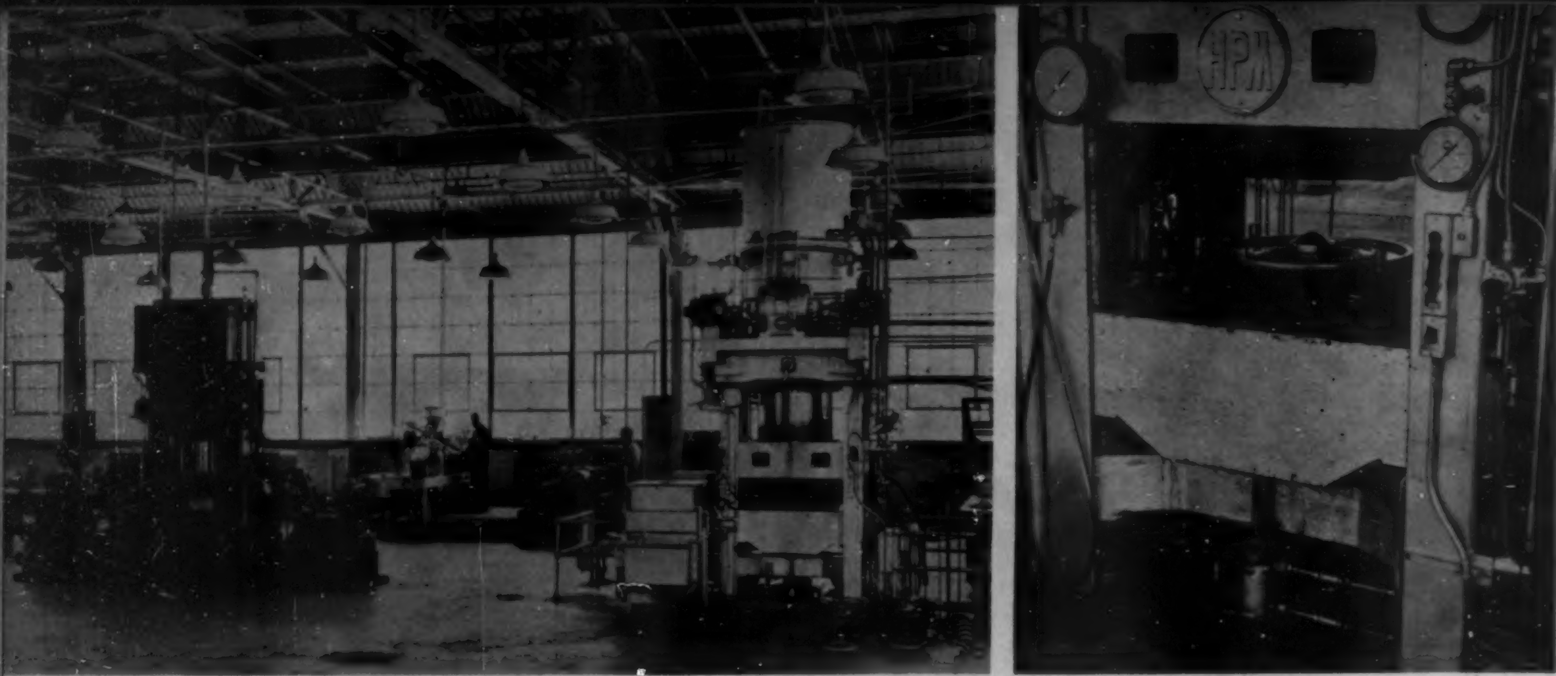
Selection of hob steel and hardening

In construction of hobs, selection of proper steel is important and necessary provision should be made for helping the flow of metal. For instance, raising up of sharp corners is difficult. Fig. 8 illustrates a hob for hobbing the landing in a land-type mold. In order to raise the metal it is necessary to provide a groove in the corner of the hob allowing the metal to raise above the required height. This raised portion in the cavity is later scraped off and a sharp cut-off is obtained.

Fig. 8, letter *A*, illustrates a closing shoulder on the hob which eliminates the use of separate closing blocks and insures uniform dimensions of the cavities.

The body of the hob does not necessarily have to be too hard. However, the hobbing portion of the hob must be hard enough to prevent scoring or clinging of hobbing iron to the hob surface. When heating the hob for hardening in a pot-hardening unit, there is little danger of oxidation and formation of scale. If there is no pot-hardening unit available, and an oven heating furnace is used, extreme care (*Please turn to page 258*)


"INSUROK"
BEETLE
BAKELITE
PLASKON
DUREZ
DURITE
SOUTHWARK PRESSES



General view of the molding room in the plant of Thermo-Plastics Inc. At the left is a vertical clamp press with two injection units; at right is one of the largest injection machines yet installed with a 600-ton vertical clamp and three injection units. Behind these is a battery of single-unit presses. Extreme right shows a close-up of the 3-unit press with automobile steering wheel ready to remove from the mold

MULTIPLE-UNIT INJECTION PRESSES

by HOWARD F. MacMILLIN

THERMOPLASTICS HAVE WITHIN THE PAST YEAR made further major advances in the ever-widening field of molded plastics. The perfection and wide-spread adoption of the injection process of molding material of this class has been an outstanding factor in this progress.

Several causes have contributed to this phenomenal increase of injection molding and the popularity of injection molded articles. Chief among these perhaps is the much shorter cycle required to produce an injection molded piece. An average of 10 to 12 cycles by the injection method requires about the same period of time as one cycle by the conventional compression molding method, the former using a thermoplastic material as compared to thermosetting by the latter. This means that in a given time with a given number of mold cavities, it is possible to produce 10 or 12 times as many pieces by the injection method.

Conversely, it is possible to produce an equal number of pieces by the injection method by using only about one-tenth the number of cavities. This fact has made possible more economical production of comparatively small runs, adding to the popularity of injection molded articles by increasing the variety and making possible the production of articles which otherwise would be impractical to mold, due to their more limited demand.

Until recently the field of injection molding has been in the production of articles of relatively small size and weight. This has been due to limitations in the plasticizing capacity and die clamping pressure capacity of available machines. While some increase has been effected through simply direct enlargement of machines of existing types, this has not met the ultimate demand for machines to mold really large articles both with and without metal inserts or cores.

To appreciate the difficulties involved, the basic functions of the injection molding process should be reviewed. Any injection press, of small or large capacity, must carry out all the following operations: 1—Feeding granular material to the heating chamber; 2—Heating the material to render it plastic; 3—Closing the mold halves and holding them closed; 4—Making contact between the injection chamber outlet and the mold inlet; 5—Injecting plastic material into the mold cavity; 6—Holding the mold closed while the material cools and hardens; 7—Separating the mold halves; 8—Ejecting the molded articles from the mold.

Injection machines of the small to medium capacity range of various American designs, have all been built with a horizontal moving die-closing member and a single plastic injection member.

The molding of large pieces introduces conditions not provided for by the foregoing conventional machine. One of these is the weight of the mold. Molds for large pieces are very heavy and when fastened to the platens of a horizontal clamp throw an unduly large load upon the tie rods, resulting in much friction and wear. It is not convenient to retain inserts or cores in the mold when its faces are in a vertical plane as is necessarily so with a horizontal moving die carrier.

Another difficulty lies in the fact that there is a limit

to the quantity of granular material which can be fed into a single injection chamber. Also there is a limit to the size of an injection chamber, beyond which it has not been found practical to go. Many large pieces are unsymmetrical having sections of unequal area or extent, greatly adding to the difficulty of filling all portions of the mold cavity before any chilling and setting of the plastic sets in.

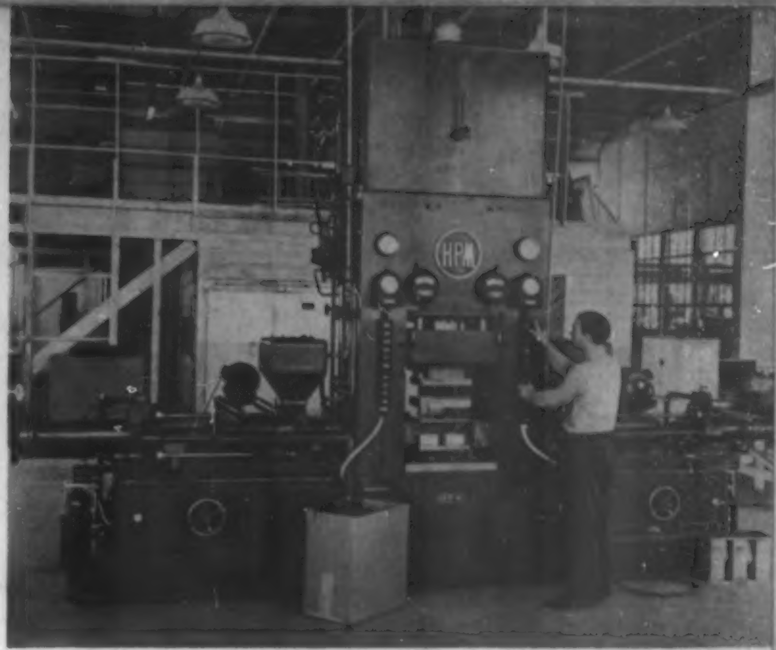
To meet these conditions, a new type of injection molding press has been developed. It has a vertical, downward moving die clamp platen, so that the die faces are in the horizontal plane. Material is injected at various points through runners along the parting line of the mold. This new press possesses several important advantages as follows: 1—Molds, regardless of size or weight, are easily placed in the machine; 2—There is no side thrust on the platen guides, eliminating friction and wear; 3—The closing of the mold is assisted by gravity, providing greater speed with minimum power; 4—As the clamp ram descends, its suction fills the space in the cylinder above with operating fluid through a surge check valve; 5—The molds are in the most convenient position for the placing and retaining of the inserts; 6—Any number of injection units may be used. Therefore, there is no limit to the size of molded pieces for which the machine may be designed; 7—If desired, the vertical machine may be used for conventional molding of thermosetting materials such as phenolics; the injection units being rendered inoperative.

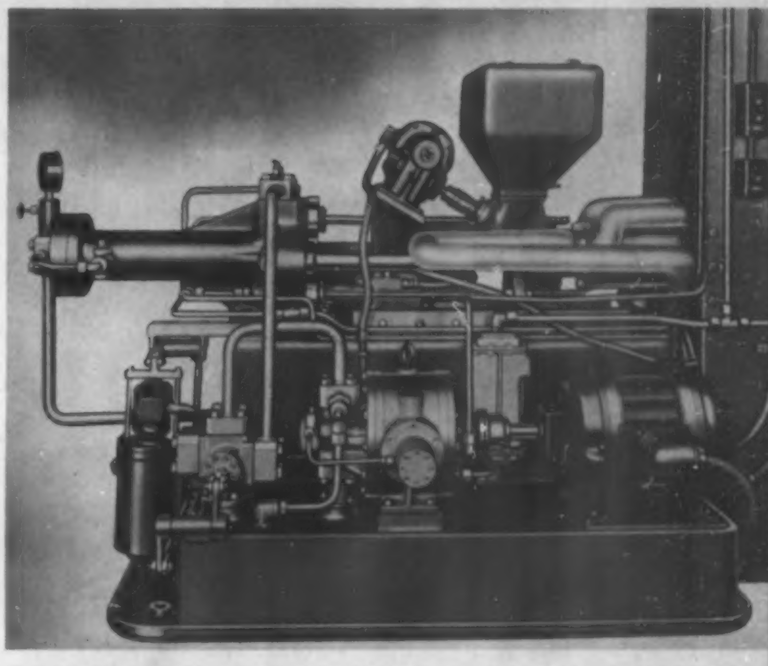
As a demand for larger molded articles makes necessary ever-increasing clamping forces, the advantage of the direct hydraulic clamp becomes increasingly important. The rapid approach and direct hydraulic pressure are being accomplished today without intervening mechanisms, a principle that has been tried and proven by hundreds of applications of hydraulically operated presses in other industries where this same principle applies with equal success.

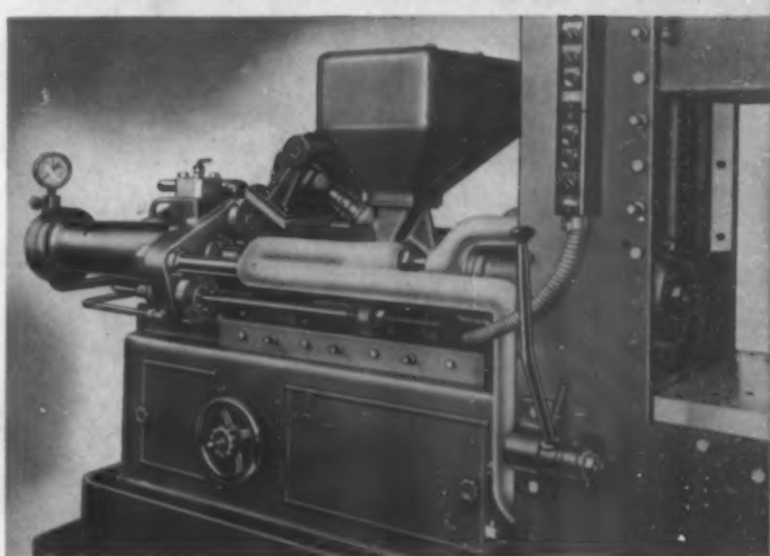
Standard independent injection units are supplied with the vertical clamp molding machine and have a capacity of 8 oz. per cycle. Larger capacities to any desired amount can be provided by using an increased number of units, or larger capacity units, and the design of the machine is such as to be adapted to any practical number or size of units without basic changes in principle.

As introducing the plastic material into the mold at several points decreases the distance it must flow to fill the mold, the use of more than one injection chamber has proven a distinct advantage and the plan will no doubt be more widely adopted as more large machines are constructed.

Approaching the problem from this angle, it can be seen that the possibilities ahead in injection molding are limited only by economic considerations. Obviously the limit has not yet been reached. In the metal working industries press capacities of 1000 to 2000 tons are not uncommon and presses of the modern self-contained type have been constructed up to 5000 tons. It can be conceived that using a clamp of 5000 tons and a number of injection nozzles, it should be possible to mold a



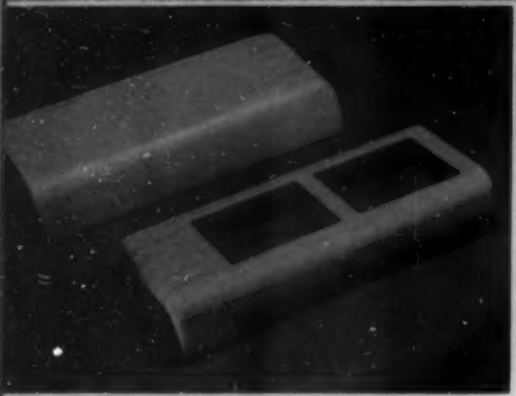




Close-up (top) of the HPM injection press with vertical clamp and double injection unit having a capacity of 16 ounces of thermoplastics per shot. Center—Rear view showing injection power unit. Bottom—Front view of one of the injection units

THERMO-PLASTICS' REMARKABLE NEW TECHNIQUE

OF INJECTION MOLDING



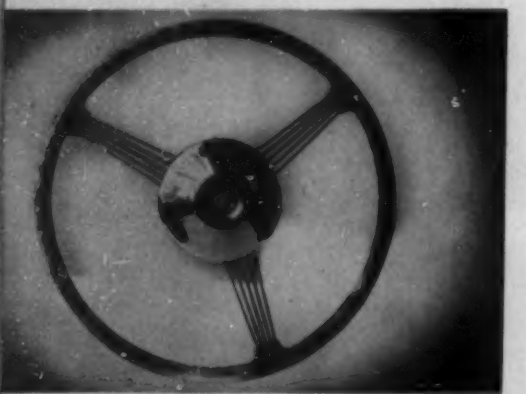
REVOLUTION IN PLASTICS—Plastics shot over metal. That's the newest thing. Thermo-Plastics by its remarkable technique *injection molds* these instrument panels and glove box doors for CHRYSLER. The metal supplies the strength ... the plastics the handsome, smooth inexpensive finish. NOTE ESPECIALLY: 8 inserts anchored in the instrument panel!

Injection Mold giant-sized plastics?

Many doubted it could be done.

No raw material was on the market to do such a job. Nowhere was there a press of anywhere near the capacity needed.

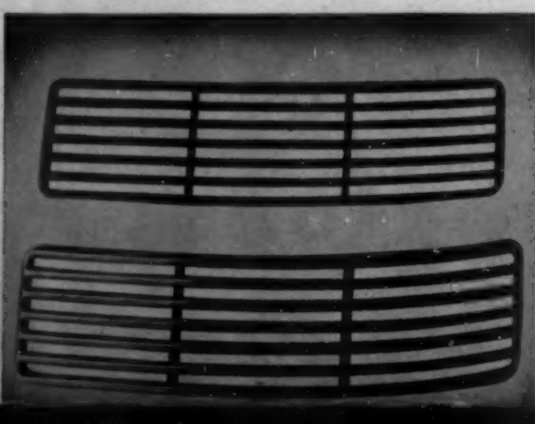
But Thermo-Plastics engineers stuck to their guns ... devised the kind of equipment required ... worked out mechanical difficulties ... experimented with war material formulae ... until today they are INJECTION MOLDING giant-sized plastics ... incorporating vast improvements in quality ... and saving up to 50% in cost of materials ... up to 500% in molding time!



AUTOMOBILE STEERING WHEELS—To meet the 1939 needs of manufacturers of the country's automobiles .... Thermo-Plastics is geared to turning out injection-molded (steel reinforced) steering wheels in a brilliant array of colors .... *each produced in less than a minute's molding time!*

LAMP SHELLS—This lamp shell for the amber fog light on autos replaces a metal shell. The old type shell, absorbing sleet, rain, etc., soon rusted .... easily dented. The new plastics shell is extraordinarily strong, extraordinarily handsome. Can not dent. Will take real abuse.

RADIATOR GRILLE SECTION measures 14.15 sq. inches in projected area! Handsome .... durable .... produced at low costs .... this job is further proof of what the right molder can do for you. Thermo-Plastics is the molder for you, by manpower, equipment, experience.



95.26 SQ. INCHES is what the projected area of this garnish molding measures! Yet it is unbelievably strong .... produced at remarkably low costs!

bath tub, for example, at a single shot! The practicability of molding bath tubs from a cost standpoint may be questionable. However, since labor and fine woods are becoming increasingly costly, there is strong probability that plastic material costs may adjust themselves to the point where it will be profitable to produce furniture and many other articles from thermoplastics.

Experienced molders do not agree as to whether comparatively small parts can be produced more economically on large or small machines. Some molders believe that the large machine has no place for small work while others feel that if large quantities of small pieces are run, they can be more economically produced on a large machine. They point out that if one operator with a $15,000 machine can produce as many pieces as three operators with three $6000 machines, they are ahead with the large machine. The correct answer to this question probably depends upon the actual size of runs. The man with the small machines has the most flexible arrangement, yet if there is work enough of a kind to keep the large machine busy most of the time, there is little gained by additional flexibility. One company, producing a large volume of automobile hardware and interior trim, uses a 100 ton vertical clamp machine with two injection units for molding sixteen escutcheons at one shot. They find this machine preferable for this class of work, although they have two smaller machines.

Control of the degree of plasticity of material as it is prepared for injection into the mold is of extreme importance in molding large articles. It is characteristic of injection molding that there is a critical temperature at which the material molds satisfactorily. At slightly higher temperature the material reaches a state more nearly approaching fluid condition with the result that the mold flashes. At a slightly lower temperature the material is not sufficiently plastic to fill the mold. In either case a loss of time and material results. A large casting may be rejected because of a small defect; therefore, accurate control of the plasticity of the material is essential.

Two methods of heating the material to render it plastic are in common use. In one, electrical resistance units are applied directly to the outside of the injection chamber. In the other a fluid medium, usually oil, is heated and circulated around the injection chamber. In either case, a thermostatic control is provided to regulate the temperature of the plastic to a point as nearly constant as possible. Where the heating element is applied directly to the injection chamber a very sensitive type of control is required to minimize fluctuation in the temperature of the plastic. There is a tendency for the temperature to over-run because the residual heat in the element and in the heating chamber reaches the material after the current has been cut off. By using rheostats or other means to regulate the current to the approximate requirement of the heater, this condition is improved.

For absolutely uniform plasticizing and a minimum number of rejects, the circulating hot oil method of heating has become outstanding. The reason for this is the ease and accuracy with which the temperature can be controlled. Some difficulty (*Please turn to page 238*)

Group of injection molded parts turned out by Thermo-Plastics, Inc. appear above while at the right, you see a close-up of the vertical clamp press, open for ejection of parts from multi-cavity molds

OVENS FOR PREHEATING

by F. H. FABER

AT ONE TIME OR ANOTHER, NEARLY EVERY manufacturer of plastic products has been (or will be) confronted with the problem of "preheating thermosetting molding materials." The advantages of proper and well controlled preheating are well known, but to refresh our memory, we list them briefly.

1. Production from each press is greatly increased because (*a*) the press closing time can be reduced, in many instances up to 60 percent; (*b*) the molding cycles may be increased as curing time is shortened.
2. Electrical properties are improved.
3. Appearance is improved.
4. Greater uniformity of products is maintained.
5. Heat resistance is improved.
6. A harder, less expensive material may often be used to an advantage.
7. Operating costs are greatly reduced because the production from each press is materially increased.

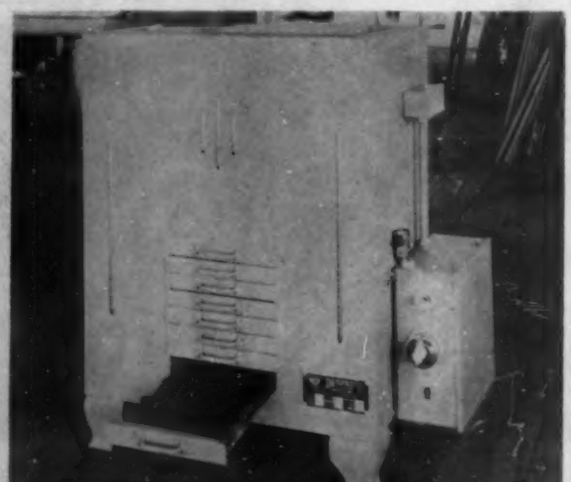
Most molders would like to preheat their plastic preforms and powders, but until recently they have been greatly handicapped. There was no standard equipment available that would give proper and controlled preheating. To overcome this handicap, many molders attempted to use steam heated hot plates and cup type preheaters. Other molders built insulated boxes, mounting steam coils in the bottom section. In some instances, fairly good results were obtained. Generally, however, the results were conceded to be far from satisfactory and for three main reasons:

1. Control of temperature was not definite, nor accurate.
2. Heat was not applied to preforms and powders evenly.
3. Heat transfer rate was much too slow.

Within the past 18 months, a new "preheating oven" has been designed which overcomes the many disadvantages of other preheating equipment and has additional advantages. In severe laboratory and field tests, this new oven has proven satisfactory in every respect. A few of the outstanding features of this equipment will be discussed in the following paragraphs.

To assure positive and uniform preheating of preforms and powders, no matter where they may be placed in the working chamber, a novel push-pull system of air circulation and recirculation is employed. A fan and motor (for mechanical convection) are mounted *outside* of the working chamber. The fan forces air through the heater chamber, then down the heat duct on the right side, and into the working chamber through a carefully designed system of adjustable baffles. These baffles not only assure correct distribution of the heated air in all parts of the oven, but also cause the air to be diffused so that the movement is rapid but smooth enough to prevent any disturbance of powders that may be placed in the oven. On the opposite side of the oven is a recirculating duct and a system of baffles. The recirculating duct is interconnected with the fan so that the cycle of operation is—fan to heater to oven to fan to heater, etc. The operating cycle is repeated many times per minute, the air being reheated and recirculated. With the heated air pushed into the oven on one side, and then pulled out on the other side, the air travel is positive and uniform at all times. On numerous occasions a total variation of only 1 to $1^1/_2$ deg. F. plus or minus throughout the entire working chamber has been recorded. While most of the air is recirculated, there is a small amount exhausted to remove moisture in the air. The amount (*Please turn to page 256*)

The two preheating ovens below in use by (left) Armstrong Cork Co. (right) American Printing House for the Blind, indicate different drawer arrangements possible for production economies. (Photos courtesy Despatch Oven Co.)



◆ ELMES ◆

PLASTIC MOLDING PRESSES

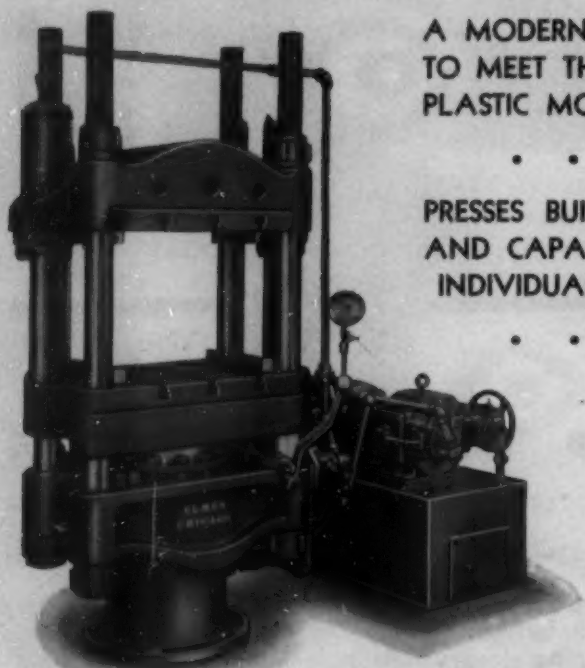
A MODERN LINE OF PRESSES TO MEET THE NEEDS OF THE PLASTIC MOLDING INDUSTRY.

• • • • •

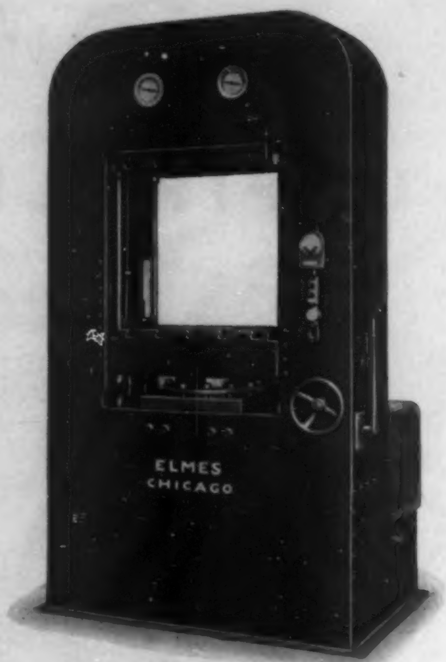
PRESSES BUILT IN ALL SIZES AND CAPACITIES OR TO SUIT INDIVIDUAL REQUIREMENTS.

• • • • •

BASED ON YEARS OF EXPERIENCE

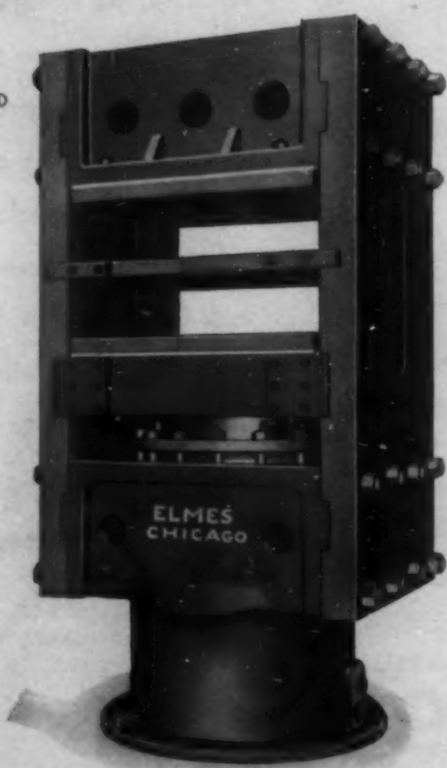


MODEL NO. 5014
SEMI-AUTOMATIC SELF CONTAINED

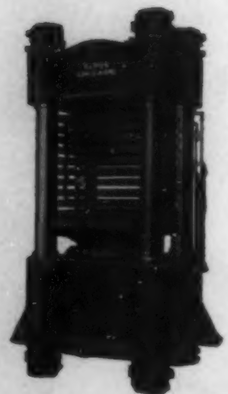


MODEL NO. 4696
CABINET TYPE SELF CONTAINED

MODEL NO. 3429-Z
LABORATORY PRESS



MODEL NO. 4857



MODEL NO. 2380

CHARLES F. ELMES ENGINEERING WORKS

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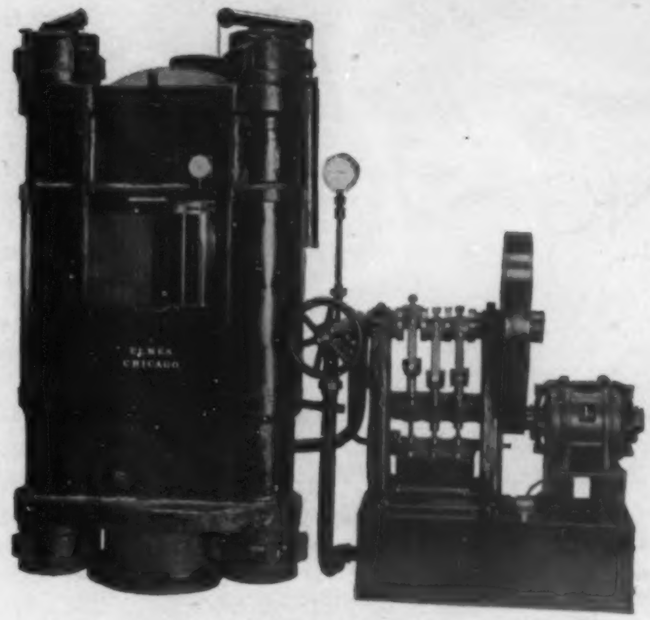
PLASTIC MOLDING ACCESSORIES

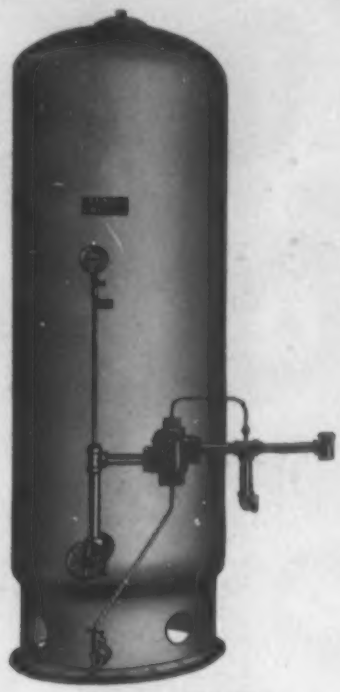
A COMPLETE LINE OF ACCESSORIES INCLUDING HIGH & LOW PRESSURE PUMPING UNITS WITH OIL RESERVOIR. AUTOMATICALLY CONTROLLED ACCUMULATOR SYSTEMS.

VALVES FOR USE IN ANY KIND OF HYDRAULIC SYSTEM FOR ANY KIND OF OPERATION.

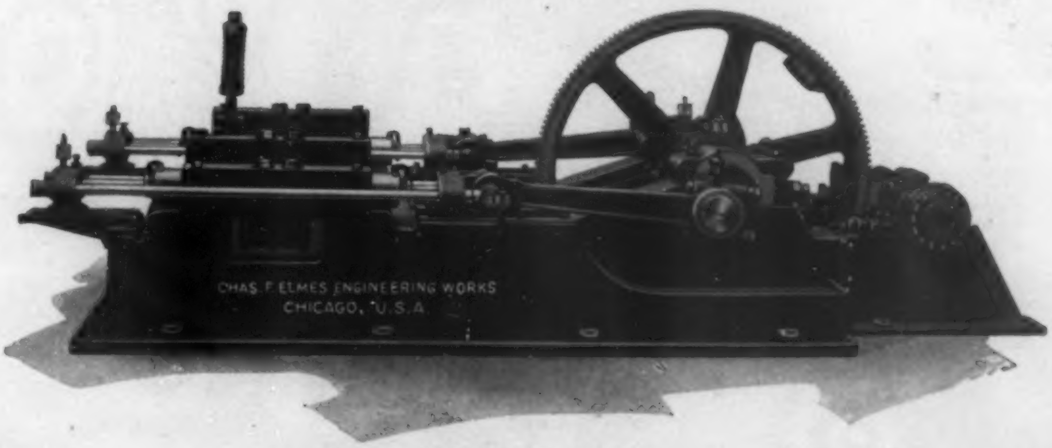
HIGH PRESSURE ACCUMULATOR AIR BALLASTED TYPE



MODEL NO. 3153
A NEW FULLY ENCLOSED DIE SINKING PRESS
COMPLETE OPERATOR PROTECTION WITH STEEL GUARDS AND SHATTERPROOF GLASS



LOW PRESSURE ACCUMULATOR AIR BALLASTED TYPE



MODEL NO. 1722
4 PLUNGER HORIZONTAL HIGH PRESSURE PUMP

CHARLES F. ELMES ENGINEERING WORKS

225 N. MORGAN ST. CHICAGO, ILL.

EST. 1851 TELEPHONE HAYmarket 0696 INC. 1895

Preforms sometimes resemble in shape the part to be molded from them, other times they are like pills or tablets. At the left you may see several molded parts and the preforms from which they were made. (Photo courtesy Auburn Button Works, Inc.)

PREFORMING

by FRANK BELLNIER

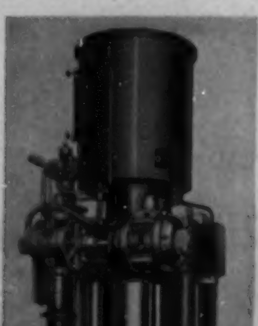
THE COMPRESSING OF VARIOUS PLASTIC MOLDING compounds into "pellets" or "pills" of a predetermined shape and weight is called preforming. The exacting standards now demanded by the molding industry in the matter of raw material savings, rapid pressing production, improved finished pieces, makes this phase of molding technique of prime importance.

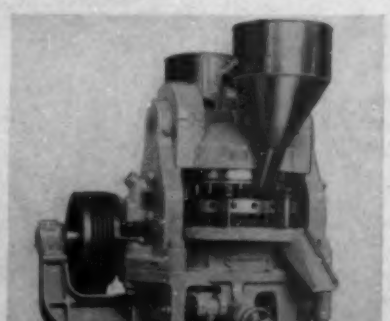
This compressing of pills is done by two separate types of machines—a single punch type and the rotary preforming press. The single punch type is necessary for general work which calls for special shapes, or where large size pieces are needed. Using this type of machine the molding material is placed in the hopper on the front of the machine, from where it is fed by gravity into the feed shoe by cam and lever mechanism properly timed. This feed shoe swings over the die cavity and spills enough material into the cell to make the proper sized pellet. When the cavity is filled the feeder shoe swings back to the starting position and while going back scrapes off the excess material that is placed in the die cavity. While the shaker shoe is returning the top punch is descending to press the pellet to the density or hardness prearranged by adjustments on the head of the machine. This type of press makes approximately 3000 pills per hour.

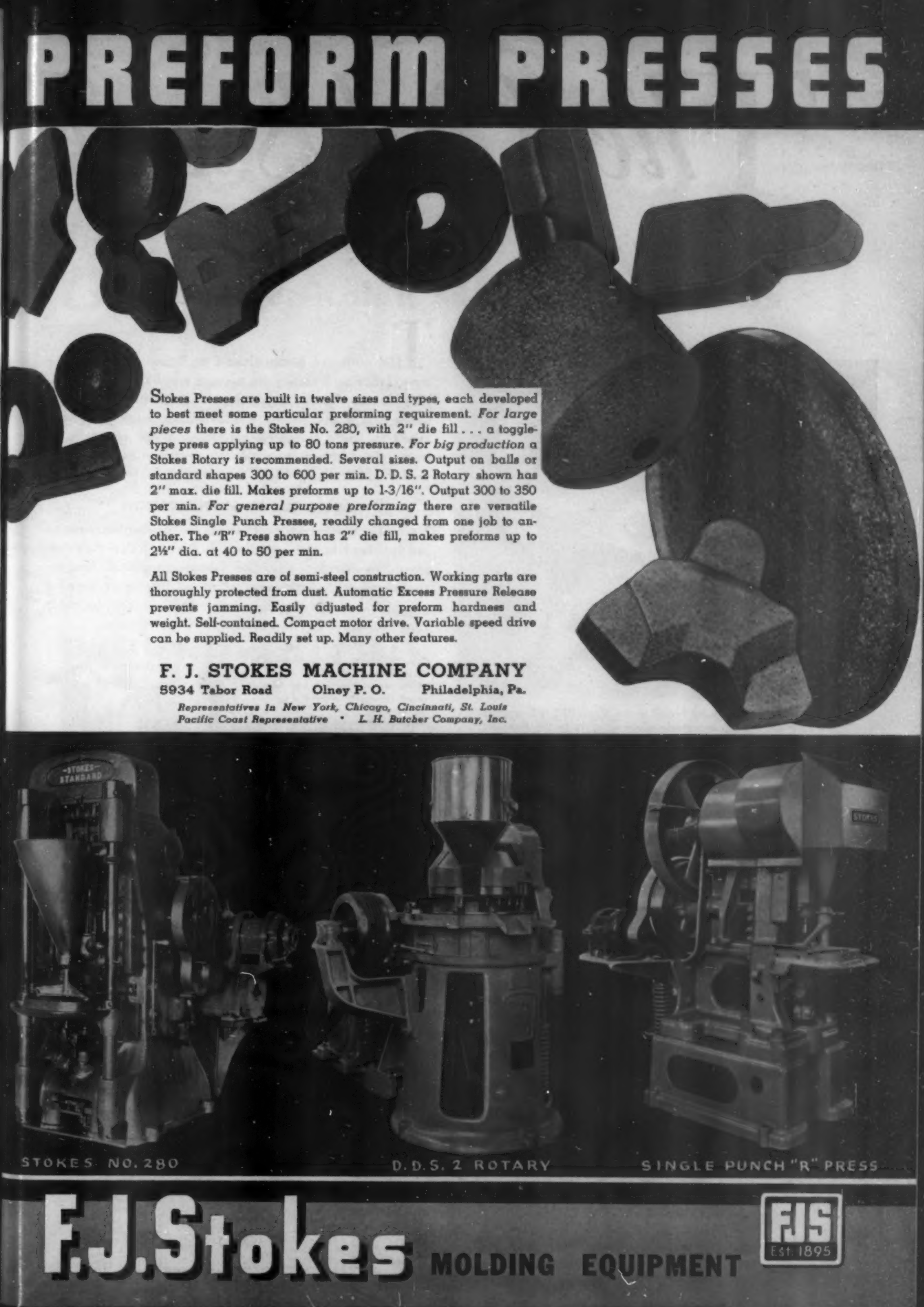
The other type, the rotary preformer, is capable of a considerably higher production of pills; ranging from 300 to 1000 pills per minute according to the size of the machine. However, this type of machine can be economically used for limited production by operating with as few pairs of punches as the job might require.

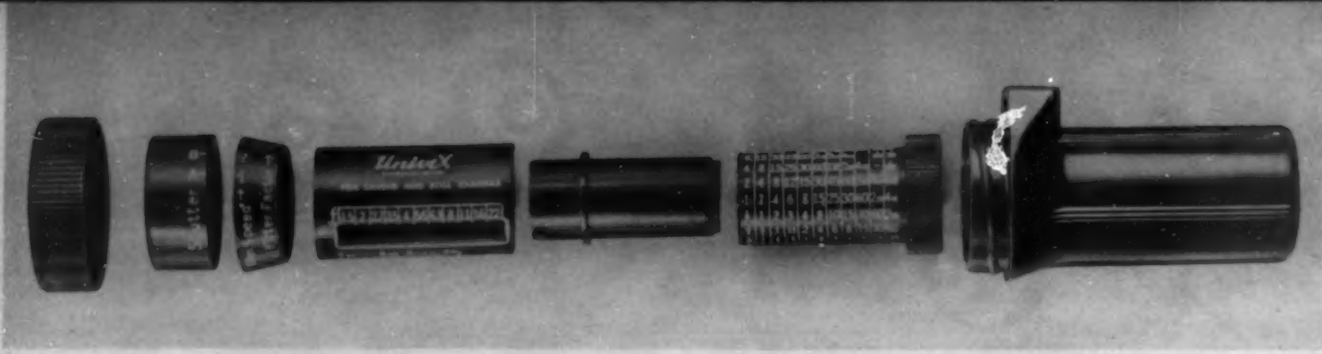
The rotary type differs radically from the single punch press. It is essentially a high production machine. The dies are set in a revolving (*Please turn to page 256*)

Three types of preforming presses are shown below. Left, a Fastraverse, self-contained electric drive by Hydraulic Press Mfg. Co. Center, a large rotary preformer by Arthur Colton Co. Right, a rotary type press by F. J. Stokes Machine Company






PREFORM PRESSES
Stokes Presses are built in twelve sizes and types, each developed to best meet some particular preforming requirement. *For large pieces* there is the Stokes No. 280, with 2" die fill . . . a toggle-type press applying up to 80 tons pressure. *For big production* a Stokes Rotary is recommended. Several sizes. Output on balls or standard shapes 300 to 600 per min. D. D. S. 2 Rotary shown has 2" max. die fill. Makes preforms up to 1-3/16". Output 300 to 350 per min. *For general purpose preforming* there are versatile Stokes Single Punch Presses, readily changed from one job to another. The "R" Press shown has 2" die fill, makes preforms up to 2½" dia. at 40 to 50 per min.
All Stokes Presses are of semi-steel construction. Working parts are thoroughly protected from dust. Automatic Excess Pressure Release prevents jamming. Easily adjusted for preform hardness and weight. Self-contained. Compact motor drive. Variable speed drive can be supplied. Readily set up. Many other features.
F. J. STOKES MACHINE COMPANY
5934 Tabor Road Olney P. O. Philadelphia, Pa.
Representatives in New York, Chicago, Cincinnati, St. Louis
Pacific Coast Representative • L. H. Butcher Company, Inc.
STOKES STANDARD
STOKES
STOKES NO. 280
D. D. S. 2 ROTARY
SINGLE PUNCH "R" PRESS
F.J.Stokes MOLDING EQUIPMENT
FJS
Est. 1895



1

Univex visual type exposure meter injection molded in seven parts by General Electric on Reed-Prentice equipment

SINGLE CYLINDER INJECTION MACHINES

by L. F. MARSH

DURING THE PAST YEAR, NO BRANCH OF American Industry has seen more rapid development and none has been more widely publicized than the Plastics Industry. Within this industry, the rate of expansion and development of injection molding has far outdistanced that of older methods of molding. During the year 1937, the capacity of injection molding machines in use in the molding plants of this country was more than doubled. This was due not alone to the large number of injection molding machines put into service during 1937 but also to the fact that these machines were of much greater average capacity than those previously in use.

Improvement in injection molding practice has proceeded along three lines, namely, molding powder, die design and molding machines. Great improvement has been made in the molding powders which were on the market and new ones have been added during the year. One marked improvement is the uniformity of granulation and elimination of fine powder, both of which have assisted the molder in producing a more satisfactory product. Another important step has been the development of hard materials suitable for larger articles. These harder materials set at higher temperatures and can be used under conditions where the older materials were unsuited.

A material suitable for injection molding which is attracting wide attention is polystyrene. While this material has been used to some extent in this country and has won wide acceptance in Germany, it is only within the past year that much attention has been given it in the United States. Polystyrene has many properties which will eventually give it a large place in the injection molding field. Among the more important of these properties are freedom from water absorption, high softening temperature and excellent electrical characteristics. Several other new materials have entered the field so that the molder now has a much wider choice of materials to select from and is better able to meet the requirements of his customer.

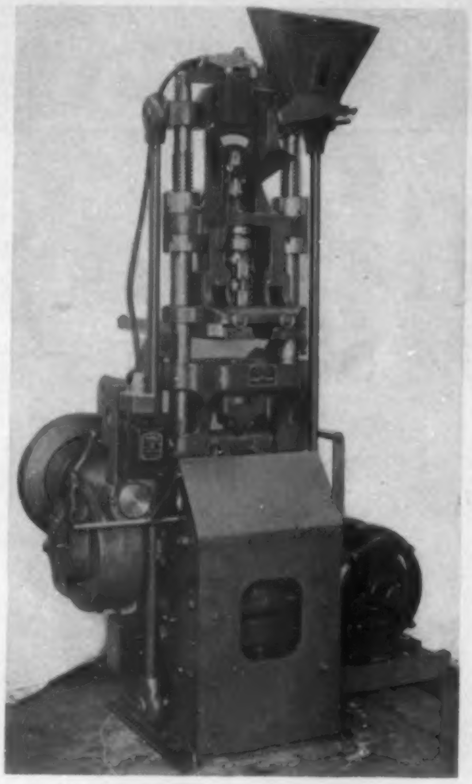
In the field of die design, much has been accomplished. As machines have been made available with larger capacity, larger and larger moldings have been attempted. Articles too complicated in design and whose specifications were too rigid for successful production a year ago are now being made. Limits of accuracy and physical and chemical properties of molded articles have been greatly improved. In the field of simpler pieces, dies are being built today with from two to four times the number of impressions that were considered standard practice a year ago.

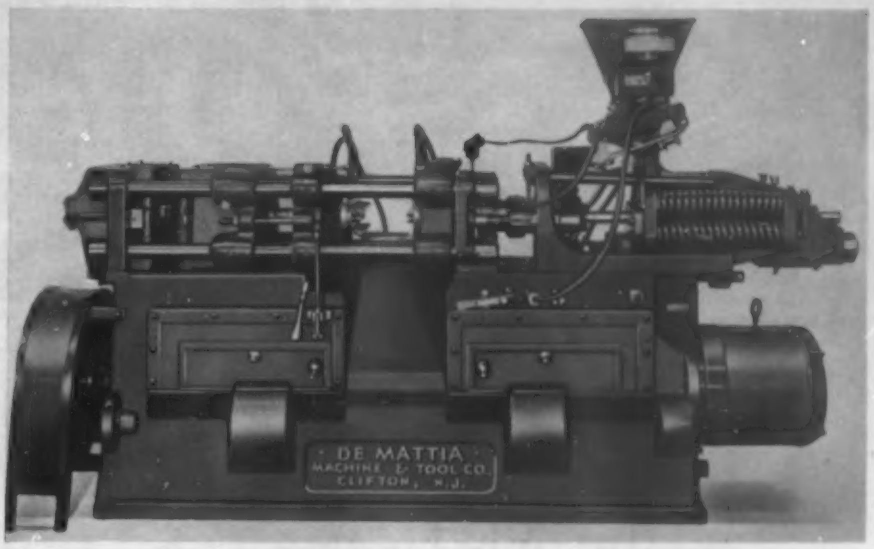
An excellent example of what may be accomplished in the way of precision molding is illustrated in the Univex Exposure Meter, Fig. 1. The cap and body are compression molded, the other five pieces are molded by injection. All parts are molded to such fine limits of accuracy that assembly is accomplished with a minimum of additional operations. Articles of this nature can be molded only where the best of technical and practical knowledge is combined in the design and construction of the die.

All this development in material and dies has proceeded hand in hand with improvement in the injection molding machine itself. These changes in machine design have not affected the general operating cycle common to all injection molding machines. In this cycle, granulated thermoplastic material is fed through some type of feeding device from a hopper into an injection cylinder. The injection plunger, either mechanically or hydraulically operated, forces the material into one end of a heating cylinder and at the same time forces a corresponding amount of plasticized material from the opposite end of the cylinder through a nozzle into a relatively cold die. Pressure is usually maintained on the plunger until the piece has set sufficiently to prevent shrinkage marks after which the plunger (*Please turn to page 220*)

DE MATTIA
INJECTION MOLDING EQUIPMENT!

Designed and built for high speed, high quality production . . . incorporating up-to-the-minute and exclusive features. DeMATTIA injection molding equipment is ruggedly built for long term, dependable and economical service.





MODEL "D" DeMATTIA INJECTION MOLDING MACHINE

Fully automatic and mechanical in operation, this machine incorporates a revolutionary idea: PRE-LOADED SPRINGS control and assure the desired unit pressure—making possible a fast, even injection cycle. This highly desirable feature is exclusive with DeMATTIA injection molding machine and permits the molding of extremely thin articles.

A motor of only 7½ HP is required.

SPECIFICATIONS

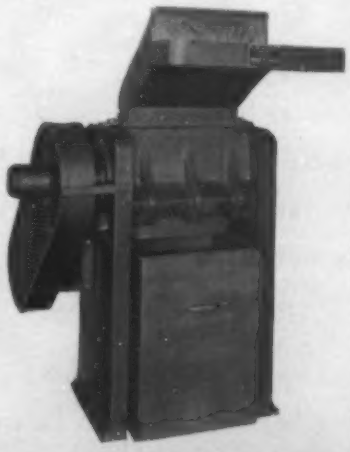
Molded material per injection . . . 3 oz.
Injections per hour . . . 120 to 450
Time for injection stroke . . . 2 seconds
Maximum projected area of molded parts . . . 24 sq. in.
Mold closing force . . . 200 tons
Plasticizing Cap.—24 lbs. per hr.
Motor furnishes . . . 7.5 HP
Maximum Mold size . . . 12" x 16", 13½" x 14", or 15½" round
Distance between die faces (stroke) when open . . . 7"
Maximum distance between mold mounting plates . . . 15.5 in.
Minimum distance between mold mounting plates . . . 5 in.
Floor space req . . . 108" x 30"
Weight of machine including motor . . . (approx.) 6000 lbs.

DeMATTIA *One Ounce Unit* INJECTION MOLDING MACHINE

This press produces up to 500 injections per hour! Made especially to meet the requirements of those whose production falls within the one-ounce range. Because of its vertical construction, inserts can be placed and molded with greater ease and safety.

SPECIFICATIONS

Molded material per injection . . . 1 oz.
Maximum injections per hour . . . 140–500
Time for injection stroke . . . $1^1/_2$ seconds
Mold closing force . . . 80 tons
Maximum projected area of molded parts . . . 10 sq. in.
Motor furnished . . . 5 HP
Maximum mold size . . . 10" x 12" or 10" by 14"
Maximum distance between mold mounting plates . . . 15"
Distance between die faces (stroke) when open . . . 7"
Minimum distance between mold mounting plates (closed) . . . 4"
Floor space required . . . 34½" x 31½"
Weight of machine, including motor (approx.) . . . 3,000 lbs.
Plasticizing Cap.—17 lbs. per hr.



DeMATTIA #1 ACETATE GRINDER

This sturdy machine for grinding plastic materials has been specially designed to meet the needs of the plastics industry. The centre casting, or "Stator," can be removed in one piece for quick and thorough cleaning. It will render years of dependable operation.

SPECIFICATIONS

Capacity 200 lb. per hour
3 HP Motor with double "V" belt and cast iron pulleys
Four steel chopper blades with inserted tool steel cutting edges
Self-aligning hour glass bearings with positive seal
Standard screen with ¼" openings
Net weight with motor 600 lbs. approximate

For information on any or all of these machines, write now to

DE MATTIA MACHINE AND TOOL CO.
CLIFTON, N. J.
NEW YORK OFFICE — 30 CHURCH STREET
Cable Address—BROMACH, NEW YORK

SINGLE-CYLINDER INJECTION MACHINES

(*Continued from page 216*) is withdrawn and the dies allowed to remain closed for a further cooling period. After proper cooling, the dies open, the piece is ejected and the dies close again ready for the next injection. The various time intervals for each part of the cycle are varied to suit the particular characteristics of the part being molded and the material used.

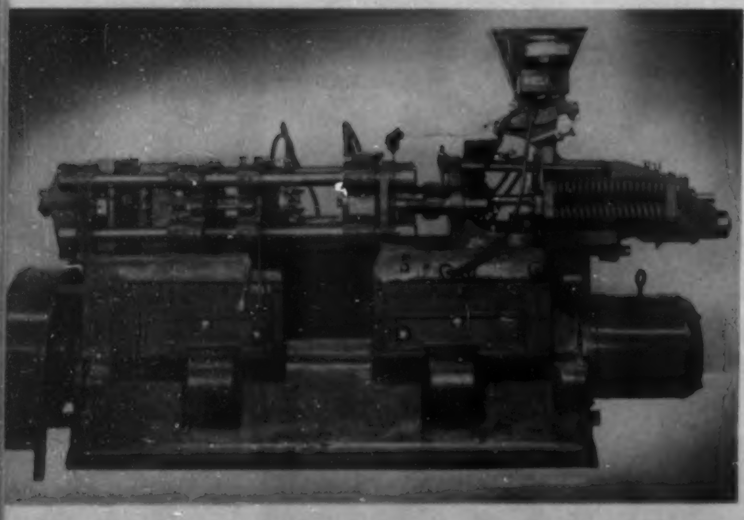
The hopper feed mechanism is usually designed to measure out for each shot the correct volume of material. The heating cylinder which may be heated either directly by electrical means or by hot oil is usually fitted with a spreader or torpedo, the function of which is to divide the plastic material into several small streams so as to secure uniform plasticizing. Automatic temperature control is applied to the cylinder. An automatic control which may be electrical, hydraulic or mechanical providing for accurate adjustment of time intervals is used to control the cycle.

The introduction of new materials with different molding characteristics and in many cases requiring higher molding temperatures has presented a new series of difficulties to the machine builder. In addition, the demand for larger injection moldings has led to the development of machines with larger capacities. These larger capacities have been obtained both by the use of larger heating cylinders and by utilizing more than one cylinder in a single machine. Several new makes of injection molding machines with single heating cylinder have entered the field during the past year.

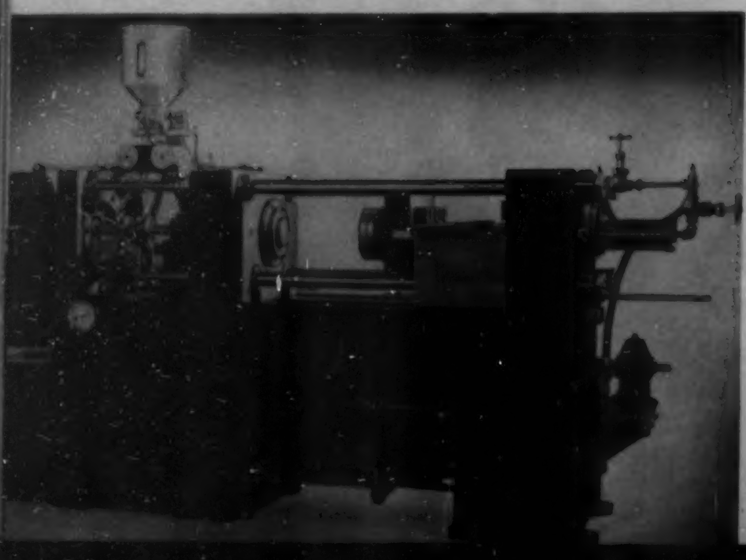
These machines follow, in most instances, principles already set forth in other injection equipment although each designer has combined these principles in different ways to secure the desired result. There are now available for the selection of the buyer, machines using direct hydraulic action for both die closing and injection, hydraulic action through toggle mechanism for die closing with hydraulic injection, full mechanical operation for both die closing and injection and finally machines using direct hydraulic action for fast traverse of the dies combined with mechanical means for locking.

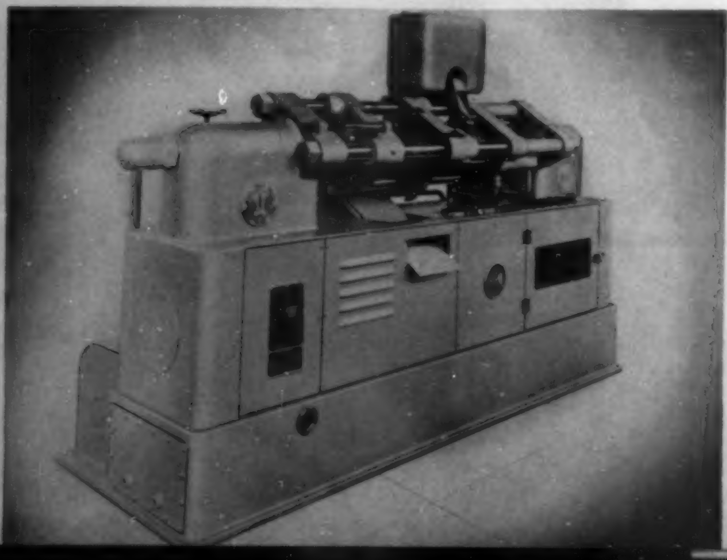
Practically all of the machines on the market are arranged for full hand operation, single cycle or full automatic. Timing devices are incorporated in the design for determining the time the injection plunger maintains pressure on the material in the die, the length of the cooling time and the length of time the dies remain open before starting the next cycle. These various time intervals may be controlled within two-tenths of a second and total time may be reduced for fast cycles to as little as ten seconds or increased to as much as two minutes where extreme time is required for cooling. In most instances, the speed of the cycle is determined by the cooling time required for the article.

The molding of articles with heavy sections and with large smooth areas requires rapid injection of the material and careful gating of the dies to secure satisfactory results. This demand for speed of injection has resulted in marked increase in plunger speed in terms of cubic inches of displacement per second and corresponding increase in the size of (*Please turn to page 224*)



During the past few years, a number of new injection presses have become available to molders and earlier presses have been greatly improved both in capacity and operation. At the left, is a new press by DeMattia Machine & Tool Co., which is fully mechanical in operation. Lower left, is an automatic injection press by the Grotelite Co. Directly below, is a hydro-power injection machine made by The Hydraulic Press Manufacturing Company





IT'S THE FINISH THAT STARTS YOUR SALES ROLLING

LUPOMATIC SUPERIOR TUMBLING EQUIPMENT AND COMPOUNDS INSURE THAT FINISH

For nearly a quarter of a century Lupomatic's Engineering & Technical Staffs have designed equipment and compounds to meet the needs of the Plastic Manufacturers and have been recognized as the originators and pioneers of the patented dry tumbling process for finishing all Plastics.

Today Lupomatic patented equipment and processes are used in leading industrial countries throughout the world—proof of highest technical development in the field.

Insure the beauty and sales appeal of your products by using Lupomatic Tumbling Machines and Compounds and provide yourself the accompanying economies that all Lupomatic equipment brings.

LUPOMATIC TYPE S 4 TUMBLER MOTOR DRIVEN UNIT SAVES POWER, SPACE—INCREASES PRODUCTION

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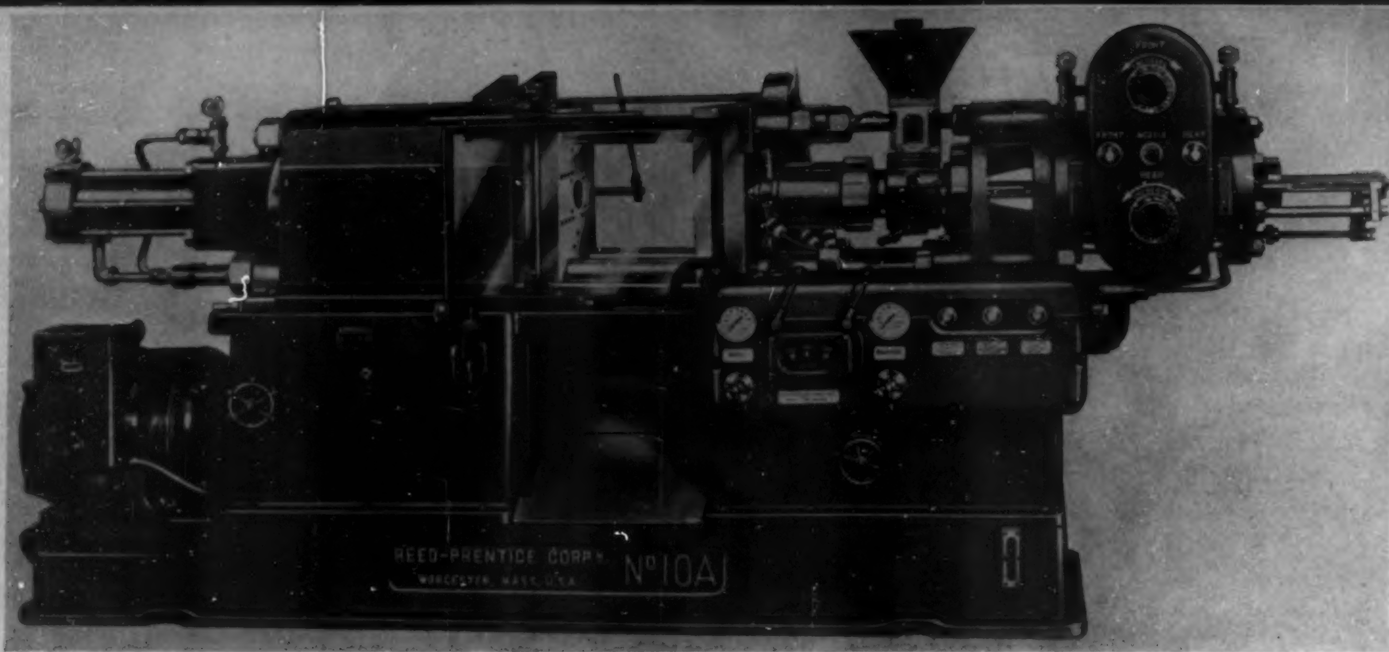
Mfrs. of Equipment and Compounds for finishing metals and plastics.

MEET THE LEADING REED-PRENTICE



First in Sales: More Reed-Prentice Injection Molding Machines in use than any other make! Over 150 deliveries in eighteen months!

And—when you seek the reason—you find it in Reed-Prentice engineering which made our earliest machines the most advanced of their day . . . and has marched them along, far ahead of the field, with a series of constant improvements ever since.

Leadership in design—
INDUCTION HEATING:

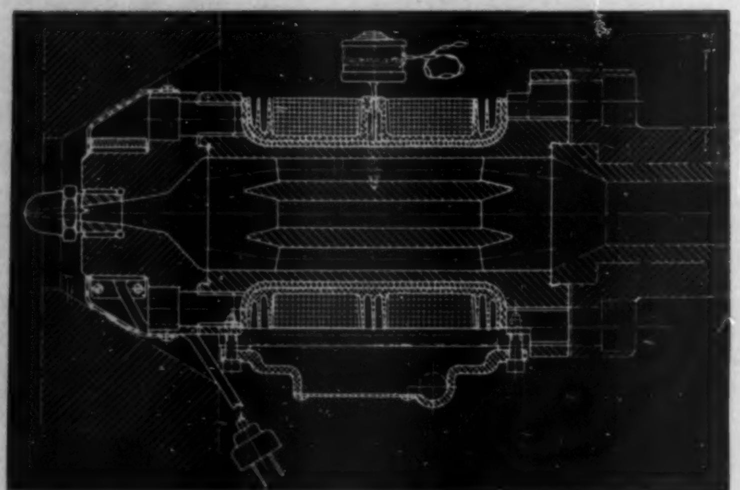
(Patent Pending)

(1) Absolute uniform heating of material
(2) More accurate temperature control of material
(3) Quicker heating and better maintenance of temperature
(4) Longer life of heating cylinder.

Specifications—No. 10A-2 oz. machine

Max. weight of material per injection—2 oz.
Max. pressure per sq. in. on material—26,000 lbs.
Maximum injection area of mould capacity—24 sq. in.
Speed of Plunger, Continuous 120" per minute

Size of die plates	18" × 20"
Capacity of feed hopper	20 lbs.
Space between bars	12" × 12"
Die opening	8"
Maximum die space	18"
Minimum die space	7"
Locking pressure toggle mechanism	100 tons
Motor recommended	15 HP 1200 RPM 60 cyc.
Floor space	147" × 41½"
Weight, approximately, exclusive drive motor	10,000 lbs.



Induction Heating Cylinder

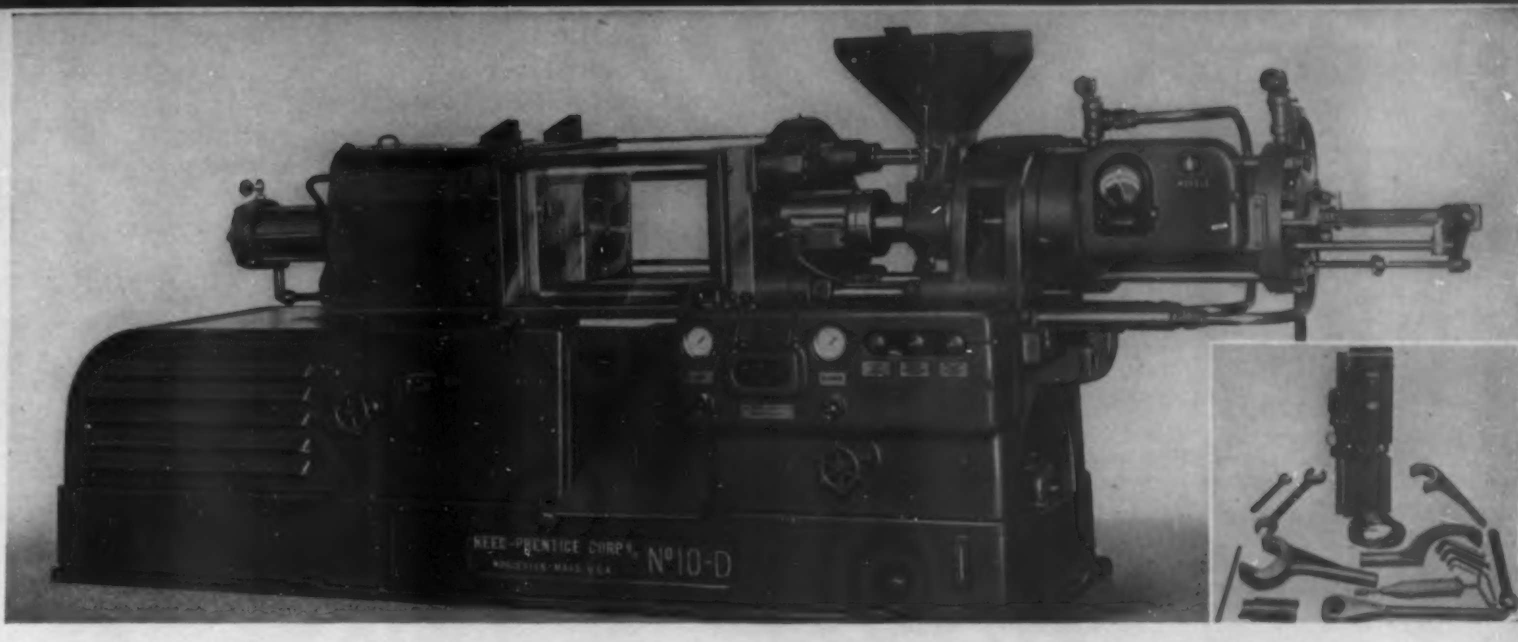
Latest of improvements . . . and representing the greatest single advance in injection molding machine design since the development of injection molding itself . . . is the Reed-Prentice Induction Heating Cylinder (patents pending) . . . a device which guarantees absolutely uniform heating of material, a longer life for the heating cylinder and more accurate and better maintained temperature control! (This method of heating is available for all previous No. 10 and 10A-2 oz. machines.)

Send today for full details about the 10A (2 oz.) and the 10D (6 oz.) Reed-Prentice machines . . . the machines which outperform all others in the field.

REED-PRENTICE CORPORATION

WORCESTER, MASS., *Main Office and Works*

Injection Molding Machines
Nos. 10A-2 oz. *and* 10D-6 oz.

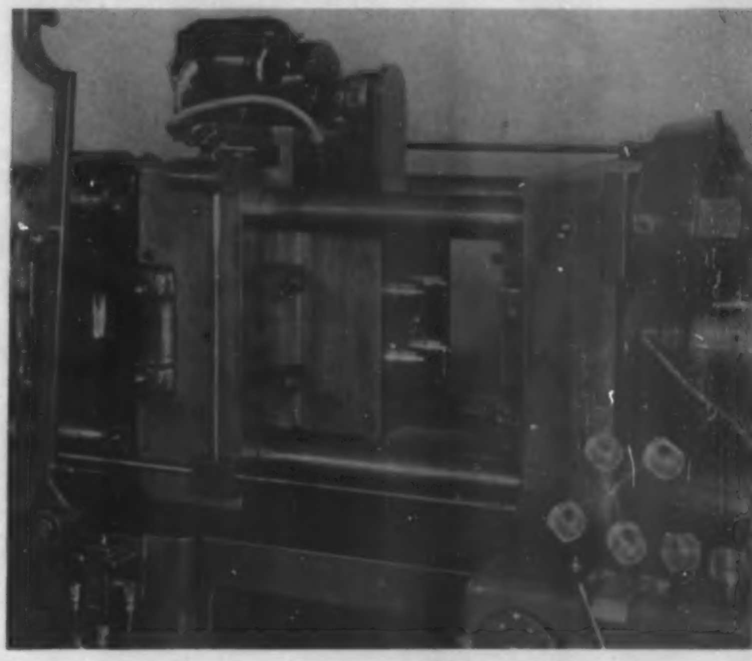


Specifications—No. 10D-6 oz. machine

Max. weight of material per injection—6 oz.
Max. pressure per sq. in. on material—20,000 lbs.
Max. injection area of mould capacity—55 sq. in.
Speed of plunger, continuous, 176″ per minute

Size of die plates	21″ × 25″
Capacity of feed hopper	35 lbs.
Space between bars	11¼″ × 14¼″
Die opening	8″
Maximum die space	18″
Minimum die space	7″
Diameter tie bars	3¼″
Locking pressure toggle mechanism	175 tons
Motor recommended	20 HP 1200 RPM 60 cycle
Floor space	180″ × 41½″
Weight, approximately, exclusive drive motor	13,000 lbs.

Assistance in mold development!



Die Miller for Molds!

Threaded Bottle Cap Mold

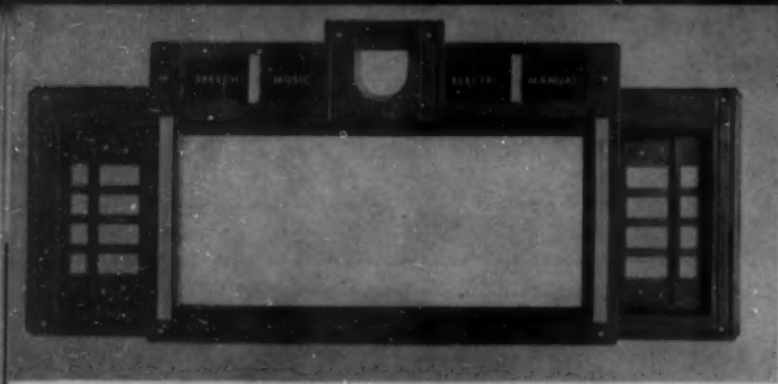
Cut above shows typical automatic mold for large threaded bottle caps. Unscrewing device is electrically operated (guard for chain and sprockets supplied). Mechanism automatically operates during cycle of machine.

No. 2U. Universal Die Miller for mold manufacture

Universal head permits milling, drilling and boring at all angles. In use by leading plastic mold manufacturers.

New York: Reed-Prentice Corp. (branch office) 75 West Street
Detroit: Kordenbrock Machinery Co., 2832 East Grand Boulevard
Pittsburgh: Barney Machinery Co., 537 Union Trust Building
Chicago: Neff Kohlbusch & Bissell
2255 West Madison Street

Cleveland: Mr. L. H. Mesker, 926 Hollenden Hotel
Los Angeles: Machinery Sales Co., 4439 Santa Fe Avenue
Buffalo: Osgood Machinery & Tool Co., 43 Pearl Street
Representatives in all principal cities and abroad.



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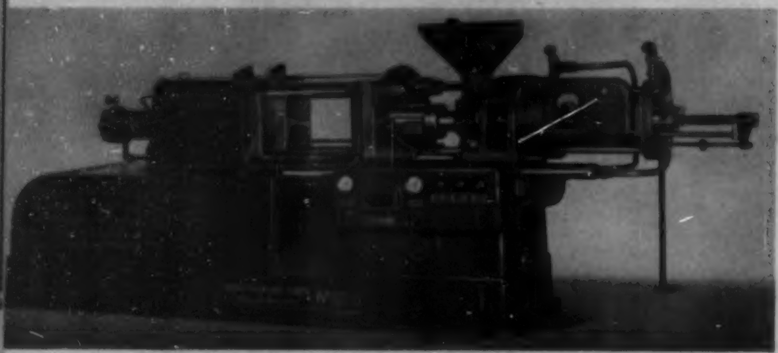

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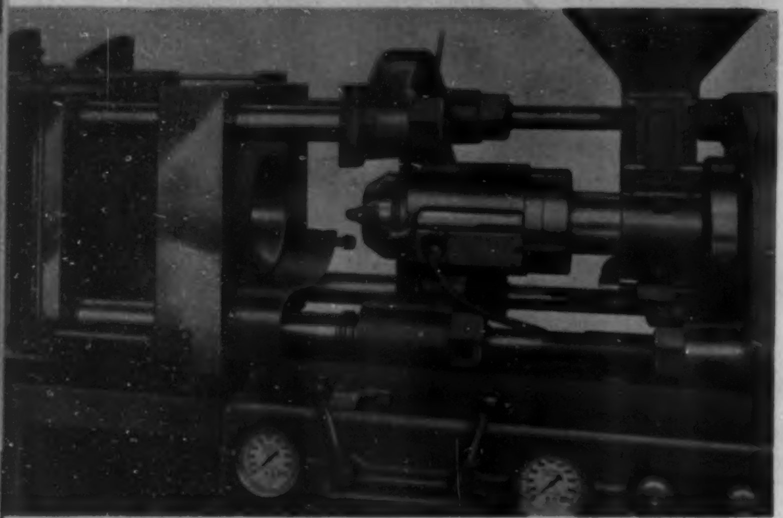

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Fig. 2—Radio bezel molded for R.C.A. by Erie Resistor Corp. Fig. 3—Reed-Prentice automatic hydraulic, 6-oz. injection machine. Fig. 4—Close-up of above machine showing patented induction heating cylinder and accessibility of nozzle

(*Continued from page 220*) motors to drive the larger pumps required. To accomplish these high rates of injection without the use of excessively large motors, special hydraulic cycles have been developed which permit the motor to deliver much more than its rated horsepower during the injection stroke. An electrically timed valve limits the length of time the motor will deliver this amount of power and thus keeps the entire duty cycle well within the safe operating capacity of the motor. This high speed of injection not only makes possible molding of pieces hitherto impractical but decreases the cycle time in simpler articles since all time saved from the moment the dies start to open until they close again and the material is in the die ready to start cooling, may be deducted from the cycle molding.

Quite as important as speed of injection is gating of the die. No amount of speed will correct improper gating nor can satisfactory results be obtained with correct gating if the speed is too slow. The effect of gating on the finished piece may often be seen best by taking a partial shot so that cavities are only partially filled. This will indicate any tendency of the material to wrinkle as it flows into the die. Once wrinkles have developed due to improper gates, no amount of pressure will remove them to the extent of producing a perfect surface. Much of the blame placed by molders on machines and material is the fault of gating.

The large molded bezel (Fig. 2) illustrates what may be accomplished in large pieces where finish is of the utmost importance. Careful attention to all the details of die design with particular attention to the gating are essential in pieces of this character.

Nearly all thermoplastic materials are relatively poor conductors of heat. This characteristic has presented a serious difficulty to the designer of injection molding machines. As a source of heat, both electricity and oil have been used but in both cases it has been difficult if not impossible to obtain an even distribution of heat throughout the heating cylinder. Since nearly all injection materials are subject to chemical changes if heated to too high a temperature for even a relatively short time, difficulty has been experienced with discoloration of light shades due to charring. In some instances where molding material is not permanently stable at these temperatures, actual decomposition takes place.

During the past year, much improvement has been made in the details of design of the conventional types of heating cylinders with the result that they may be operated at higher temperatures with increased rates of production. All of these improvements, however, have been somewhat limited in their extent by the poor conductivity of the molding powder and by the fact that many of the surfaces of these cylinders received their heat by conduction from some other portion of the heating cylinder and therefore necessarily operate at a lower temperature. The larger the cylinder, the more difficult it becomes to provide a design which will keep this temperature difference within operating limits.

To overcome this difficulty of heat distribution in large heating cylinders, one manufacturer of injection molding machines has recently introduced an induction heating cylinder which is illustrated in Fig. 3. In this cylinder, the material is distributed to several relatively small diameter channels extending lengthwise of the cylinder. The size of these channels is such as to permit thorough plasticizing of the material before it reaches the nozzle.

As indicated in Fig. 4 the main body of the heating cylinder acts as the core of an induction coil. Current flowing through the induction coil induces eddy currents in the hardened steel core which is slotted to produce a flow of eddy currents that will in turn distribute the heating effect evenly throughout the cylinder. Since the heat is generated directly in the cylinder itself, it is obvious that certain very important operating characteristics are obtained. (*Please turn to next page*)

Get Greater Press Efficiency with AMERICAN *Seamless* FLEXIBLE METAL TUBING

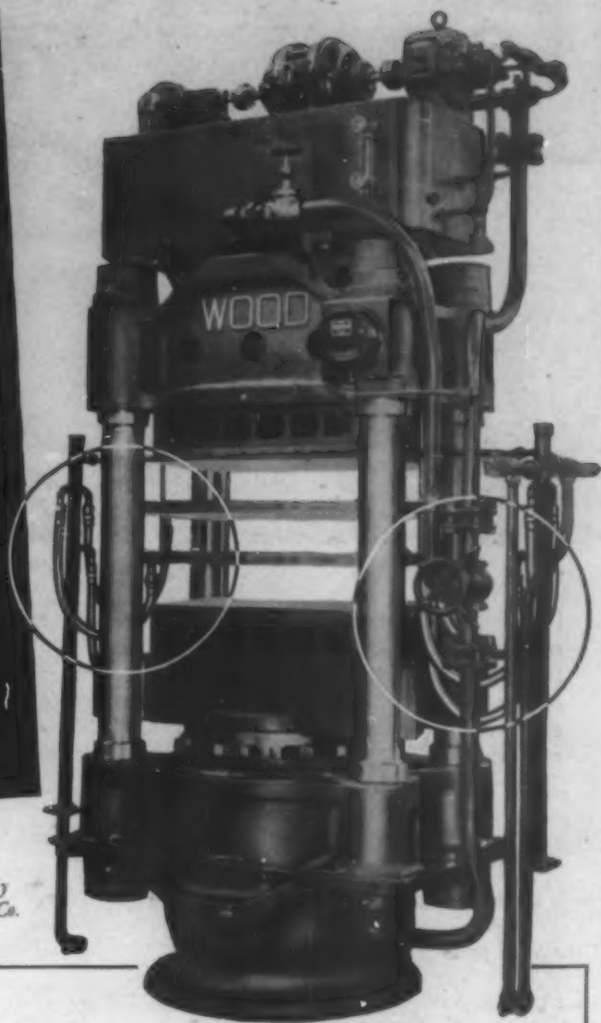

Photo courtesy R. D. Wood Co.

FOR flexible connections that will give top-notch service in heating and cooling your dies and platens, use *American Seamless.* It is available in true bronze, Monel and other metals—specially fabricated from *seamless* tube, then strongly reinforced with high tensile strength wire braid.

Leading manufacturers of steam heated plastics molding presses are standardizing on this seamless product to help safeguard efficient performance and low maintenance costs.

Molders, too, are replacing packed swing joints and inferior hose connections with *American Seamless.* Available with either welded or "heat-proof detachable" fittings, it is simply installed and easily disconnected for moving from one mold to another.

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For a self-draining connector we have especially developed the new *improved* American Bracketube . . . a length of Seamless Flexible Bronze Tubing with patented brass bracket attachment. This mechanism controls the *flexing* and the *position* of the tubing, thus completely eliminating all possibility of water pockets forming in the loop. Hundreds of installations prove that, once properly set up, American Bracketubes save money on maintenance, speed up production and cut operating costs.

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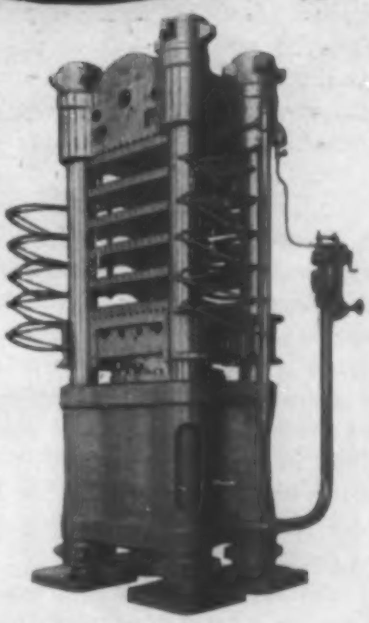

Photo courtesy Baldwin-Southwark Corp.

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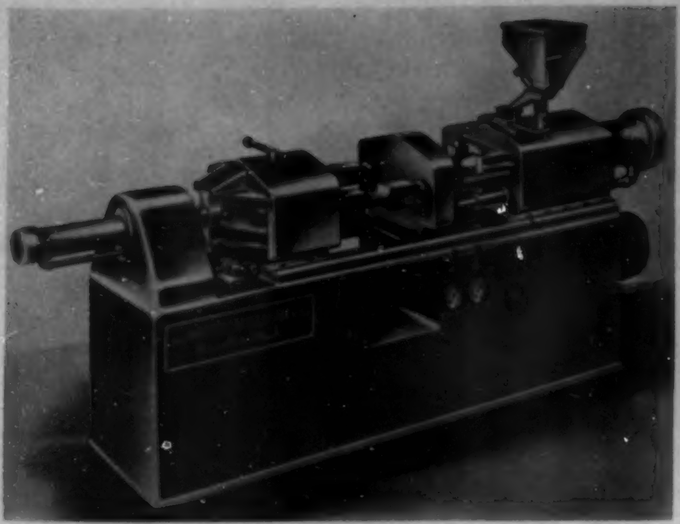

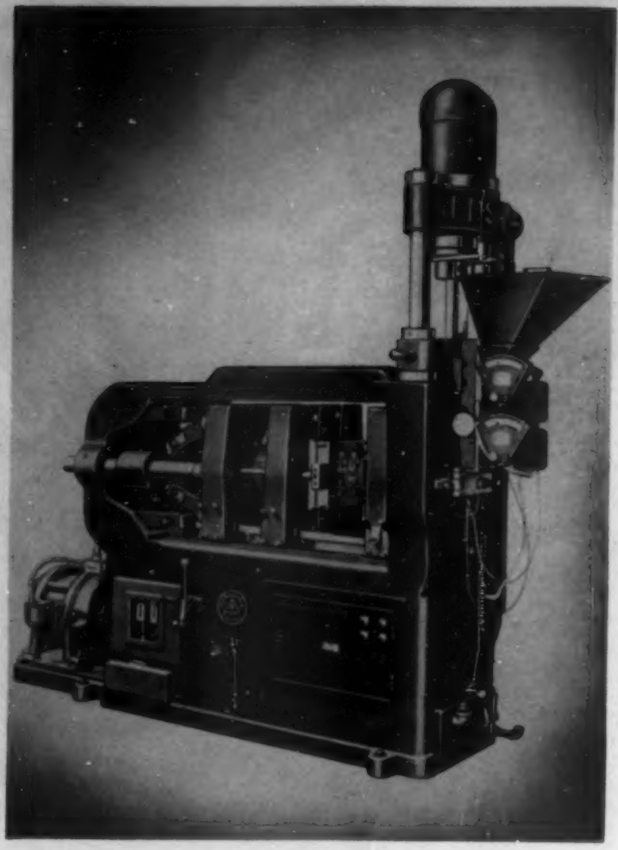

Directly above, is the new Wasco injection molding machine made by The Watson Stillman Co. At the right, is the Lester-designed fully automatic injection molding machine distributed by Index Machinery Co. This single cylinder machine has a vertical clamping unit hydraulically operated and is built with a capacity of 4, 6 or 8 ounces

(Continued from preceding page)

Of primary importance is the practical removal of the limitation of size of cylinder and the possibility of raising the capacity of a single heating cylinder to many times that obtainable by other heating methods. At the same time, it becomes feasible to deal with much higher pressure on the material and still stay within safe stress limitation in the heating cylinder structure. This need of higher pressures has already demonstrated itself in connection with some materials now on the market and is likely to become increasingly desirable with wider application of the harder materials. A further advantage of the induction heater is the ease with which it is possible to incorporate in the design a high rate of heating without endangering the life of the coils. Since the heating is generated directly in the cylinder and not in the wire of the coil, the temperature of the coil can be kept well within the capacity of standard grades of wire wound with heat resisting insulation. This results in almost unlimited life for the induction coil provided it suffers no physical accident.

To secure a rapid heating rate for starting up the machine and at the same time to provide a normal rate when the cylinder is up to operating temperature, the coil on the cylinder is divided in two parts. The separate coils are arranged in conjunction with an automatic temperature control instrument so that they may be connected either in parallel or in series. When the coils are connected in parallel the rate of heating is approximately six times as great as when they are connected in series. This rate of heating is fast enough to raise the cylinder from room temperature to a temperature of 400 deg. in less than five minutes. The control of the heater is automatically taken care of by the control instrument. Whenever the temperature of the cylinder is more than 6 deg. below the temperature setting of the control, the induction coils will automatically be thrown into parallel connection in which case the temperature will rise at a rate of slightly more than one degree per second. When the temperature reaches a point six degrees below the setting of the instrument, the coils will be automatically connected in series and the heating will continue without interruption but at a greatly reduced rate.

Should the demand on the heating cylinder, due to a high rate of production, be greater than the series connected coils can take care of, then they will automatically be thrown into parallel connection with resultant rapid rise in temperature until the correct temperature has been restored. All operating functions are automatic so that the operator need only set the control instrument at the desired operating temperature and that temperature will be quickly arrived at and accurately maintained to meet the demand.

The successful development and application of this new induction heating cylinder will greatly broaden the field of application of single-cylinder injection molding machines. Exactly how far the capacity can be extended before limitations are reached is not known but present indications are that it will be feasible to build cylinders of this design having several times the capacity of any yet offered on the American market.

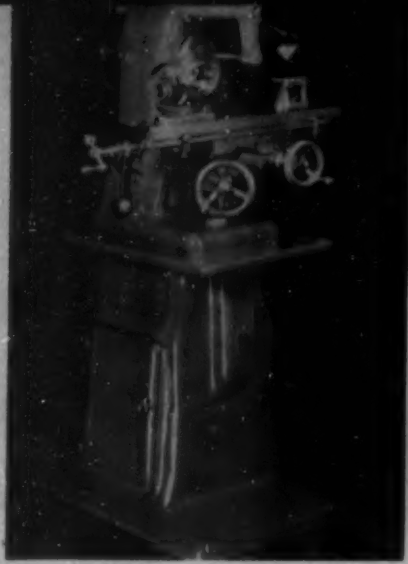  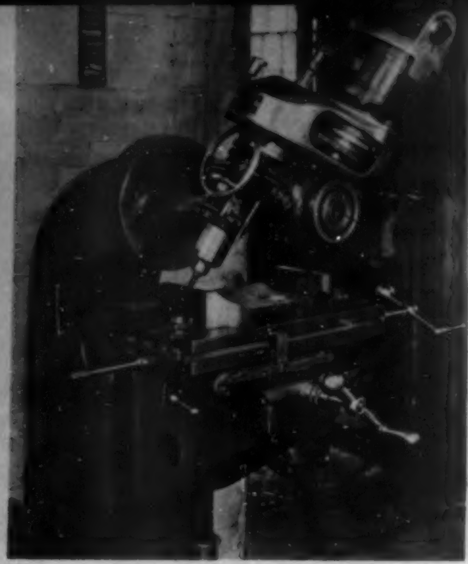

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Fig. 11—This milling machine is equipped with preloaded ball bearings and is designed for tool room and laboratory work. (Photo courtesy Hardinge Brothers, Inc.) Fig. 12—This vertical milling machine is shown in operation at the Chicago Molded Products plant. It can be readily converted into a die duplicator. (Photo courtesy George Gorton Machine Co.) Fig. 13—Die milling machine with tilting head designed especially for the production of injection molds. (Photo courtesy Reed-Prentice Corp.)

MODERN PLANT EQUIPMENT

(*Continued from page 188*) and by providing suitable notches, the valve will automatically function for a complete molding cycle. The press operator has only to manipulate one lever—the press closes under low, then high pressure; it remains closed until the plastic material is properly molded; water is admitted for cooling the mold and returns to the pipes; the pressure releases and the press opens, ready for the next cycle.

A hydraulic gage at each press is essential for occasional checking of the hydraulic pressure per square inch on the press ram, and also the total tons pressure exerted by the press on the dies. A master steam gage controls the main line steam pressure.

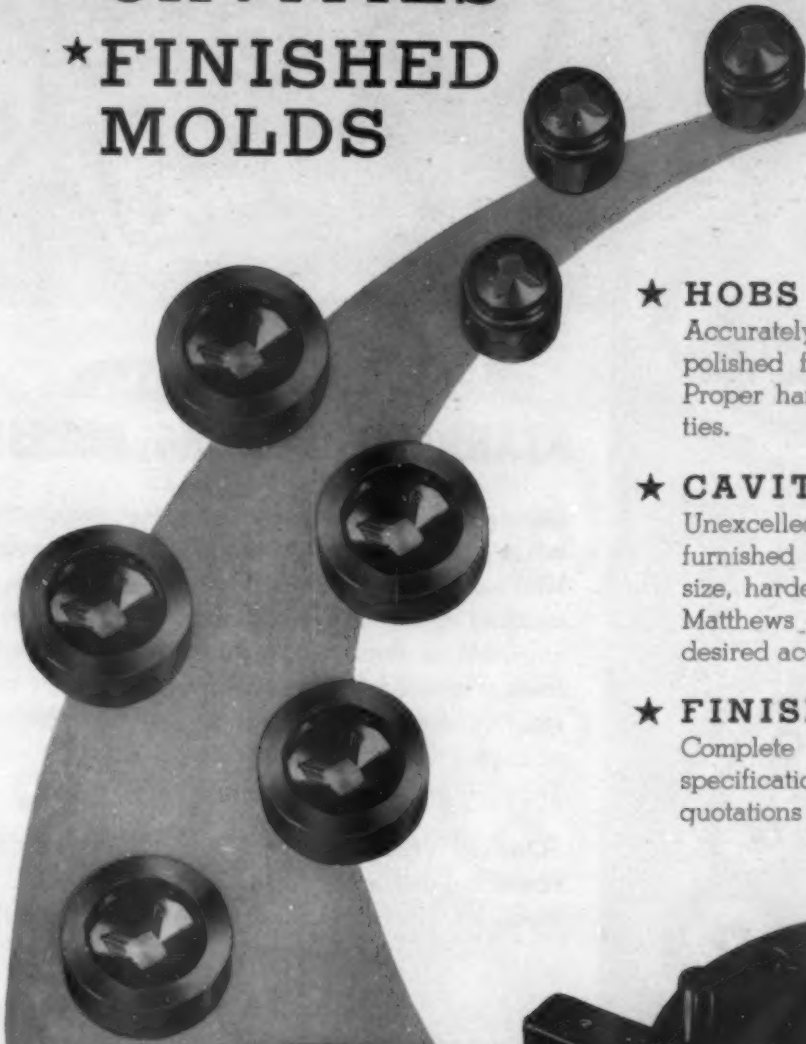
The main ram of the molding press requires leather packings to hold the pressure which causes the ram to lift in closing. These are usually of a cup or U type and must be sturdy and strong enough to withstand heat and pressure, and the pounding of continuous operation. Oak-tanned packings are sufficiently dependable where the heat used is not too intense, but for higher temperatures chrome-tanned packings are more satisfactory.

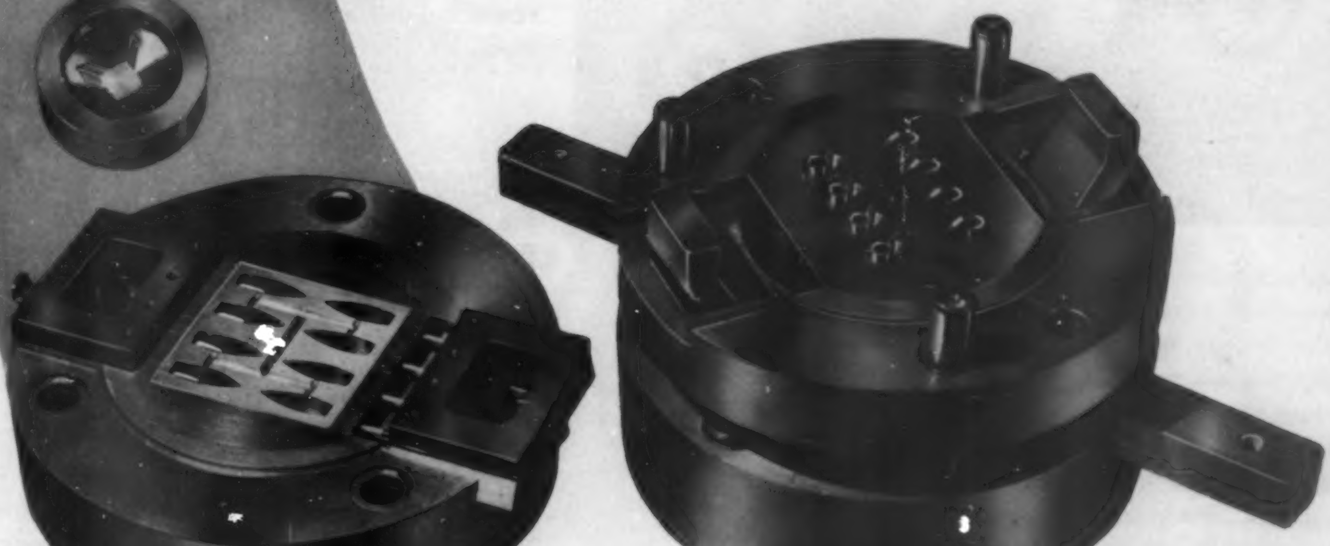
Air compressors. The power plant houses one or more air compressors which provide air pressure wherever needed. At each press, a flexible hose equipped with a nozzle valve, is placed within convenient reach of the operator and used for blowing flash and small particles from the dies between molding cycles. Air pressure must also be available in the finishing department for removing dust from molded pieces, and in the pilling room for quick cleaning of preform presses and booths between runs of different colored material. Where an air ballast type of accumulator is used, the air compressor is employed to give the unit its initial charge and to replace any losses of air that may occur in the system over a period of time.

Water salvage. An enormous amount of water is used every day in the average molding shop and under some local water supply conditions, this becomes an item of considerable expense. However, by installing appropriate equipment, the cost of water can be reduced materially. For example, one of the newer molding shops has adopted a system which makes it possible to reclaim and cool practically all water from the presses. Warm water leaving the presses is combined with condensate and returned through a line in a trench beneath the floor to a hot water storage tank under the power plant floor. Part of the hot water in this tank is pumped up to a tower on the roof where it is air cooled and then pumped through a pressure tank to the presses for chilling the molds. The remainder of the hot water is used for boiler feed. This process is repeated over and over again and the only new water necessary is whatever small amount is lost in evaporation, during the changing of molds, or through small leaks. All water used in this particular shop is treated and softened to eliminate impurities and protect the lining of the boiler, molds and piping.

Piping. The force created in the power plant must be conveyed to the molding room and other sections of the shop through pipe lines of proper size and construction for each element—steam, low hydraulic pressure, high hydraulic pressure, cold water, and compressed air, as well as hydraulic return and a combined condensate and warm water return line. With so many pipe lines, it is necessary to arrange them as compactly as possible, at the same time leaving sufficient space around them for easy maintenance. Sometimes the various pipe lines are carried along overhead; sometimes they are grouped in a trench between two rows of presses. In a recent installation, the pipes are arranged horizontally directly behind the row of presses and arched over passageways and at press intersections.

The constant up-and-down movement of the molds requires a pliable conveyor of steam and cold water from the main pipe lines to the press and return. Flexible metal tubing or swivel joints or couplings are generally used for this purpose. One type of conveyor, a one-piece flexible metal hose and coupling unit, consists of corrugated, seamless, alloy-bronze tubing, covered with wire braid and joined with heat-proof, non-pack couplings. The tubing should be installed in (*Please turn to page 232*)





(*Continued from page 228*) a loop large enough to bend easily, and long enough to allow for short straight sections where the tube enters the rigid coupling to prevent flexing stresses at these points. With this may be used a mechanical support which holds the flexible hose in a self-draining position at all times and also controls the bending of the tubing.

Pilling room

Plastic material, as delivered to the molder, is in powder form about the consistency of granulated sugar. To produce molded parts efficiently and with as little waste as possible, just enough of the powder, either loose or in compressed form, must be included in each charge to properly fill the mold. Where but few charges are required, loose powder may be weighed by hand on an accurate scale or balance, and this can be done in the pilling room or at the individual press. If a quantity of charges are necessary, measuring can be accomplished on a simple machine which automatically drops powder from a hopper into suitable containers.

Compressed pills or preforms are preferred wherever possible because they speed up the loading of the molds and are cleaner and easier to handle. The two types of preform presses most often seen are a single punch—for making oversize tablets or odd shapes and sizes in nominal quantities—and a rotary press—for consistent production of large quantities of tablets of the same size. On most preform presses, the pressure is applied only with the top punch and consequently, the tablet is usually harder on the top surface than it is at the bottom. A new dual compression preforming press that has made its appearance within the past year, applies pressure on both sides of the tablet, making for uniform density throughout.

An electric vibrator, attached to the die on a preform press, will help settle the powder so that the die fills properly leaving no air voids. A similar vibrator connected with the hopper, keeps the material flowing freely with no danger of its arching over or clogging.

Preform presses, especially those running light colors, should be placed in individual booths or otherwise separated to prevent contamination. The tiniest speck of a foreign color will show up in the molded piece and there is no possible way of removing it. An exhaust hood, connected with a competent dust collection system, should be located over each powder hopper to remove flying bits of powder and dust that might be injurious, or at least unpleasant, to workers. This system is also useful for salvaging molding material that might otherwise be a total loss. Compressed air should be available at each preforming unit for cleaning the press and the area around it during long runs and between changes of color.

Preforms and molding compounds, too, should be stored in a room where the temperature and humidity is controlled, to give the best results. Racks for storage of idle preforming dies should be conveniently located.

Accessory equipment in the press room

Enough molding material, whether in tablet or powder form, must be relayed to the presses periodically to keep them running on schedule. These deliveries may be made by electric trucks, hand trucks, overhead bucket conveyors, or tote boxes according to the needs and facilities of each individual shop.

Much of the plastic material, before it goes into the mold, is preheated in ovens located near each press. With this preliminary heating, the material is softer and flows more quickly and evenly into every section of the mold, without disturbing any inserts that are to be molded in. The press can be closed faster and the curing time reduced, substantially increasing the number of molding cycles per hour. Preheated material is said to produce a better molded piece of greater uniformity, improved electrical qualities, heat resistance and appearance.

Many such ovens are rigged up in individual molding shops, but others are now available in different types and sizes which are constructed especially for the purpose. One typical unit is built with eight drawers and each drawer has four trays for preforms. A fan forces air through the heating chamber and into heat distributing ducts on the right side of the oven. Heated air is forced horizontally through and around the drawers to a recirculating duct on the left side of the oven which is interconnected with the fan. By having the fan of proper capacity, the cycle is repeated many times per minute, which assures uniformity of heat throughout the working chamber and permits close temperature control. These ovens may be heated by electricity or gas, whichever is more economical under local rates.

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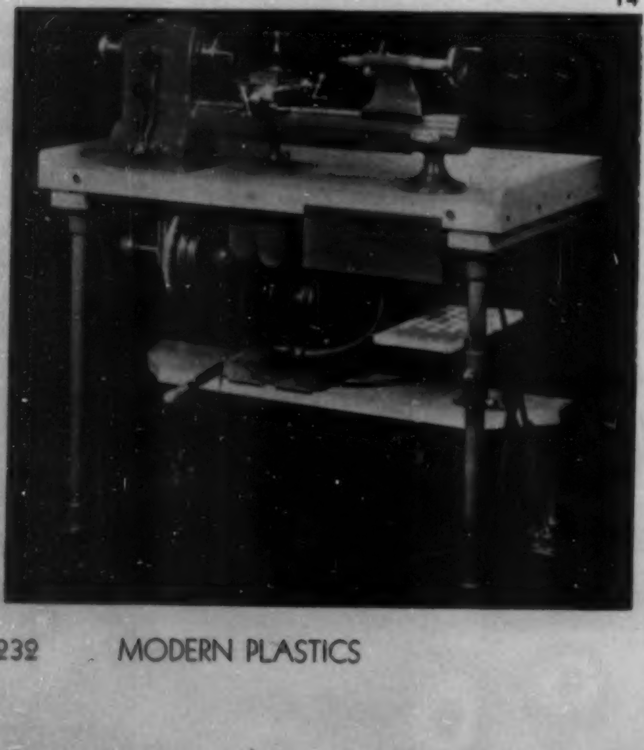

Fig. 14—This precision bench lathe equipped with preloaded ball bearings may be used in production, tool room or laboratory work. It is designed for highly accurate, closely controlled operations in any of these three types. (Photo courtesy Hardinge Brothers, Inc).

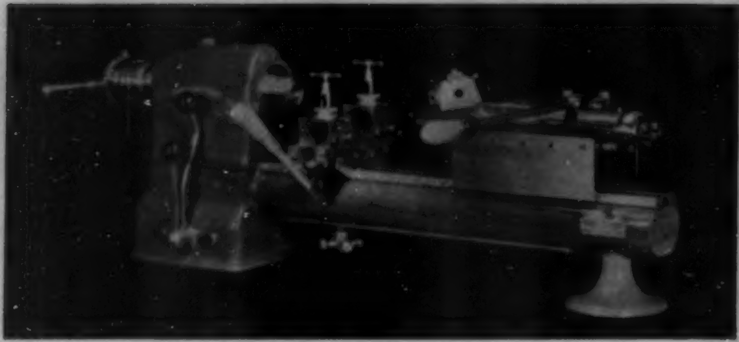

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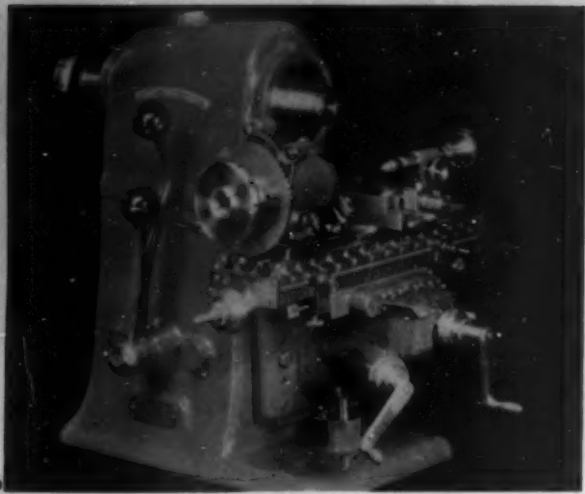
Fig. 15—Experimental, production or tool room use is the purpose of this precision bench milling machine. Fig. 16—Its companion machine, the laboratory milling machine is designed for laboratory and tool room work (Photos courtesy Hardinge Brothers, Inc.)



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Smaller ovens of a gravity convected type are available for those who feel they cannot afford the mechanical convections described above. These units are also manufactured in several sizes and can be heated with electricity or gas. (See Article, "Ovens for Preheating," elsewhere in this issue.)

After the material is heated, it is ready to be placed in the mold. Wood or metal loading boards speed up the charging of multiple cavity molds and as a rule, these are made in the shop to fit each new mold as it comes along. A common type of preform loader is built with a double bottom and has the same number of cavities in the same position as those in the mold. A handful of preforms spread over the surface quickly fills each depression; the loader is properly inserted between the dies, the sliding bottom is removed, and the preforms drop into place in their respective cavities. While one lot is being formed, the loader is refilled ready for the next cycle. Powder loaders are made in much the same manner except that larger cavities are necessary for the loose material.

Once the mold is loaded, the pressman manipulates the control valve, usually located within easy reach at the right of the press, to start the molding cycle. A manually or electrically operated timing device, preferably one that flashes a light when the cycle is complete, is desirable at each press to avoid under-curing or overcuring the material. When the proper period of time has elapsed, the press is opened and the pieces ejected with the aid of miscellaneous unloading contrivances. These may consist of a chuck, driven by an electric drill for removing threaded parts, or a comb-like gadget which enables the operator to lift all parts simultaneously from the lower dies. A blast of compressed air blows out any loose flash that may drop into the dies or where this isn't sufficient to thoroughly clean the mold, soft brass or copper scrapers may be required to dig out the scrap preparatory to loading the mold for a succeeding cycle. Each operator should be equipped with suitable gloves or pads to protect his hands while he is working on molds or about the press.

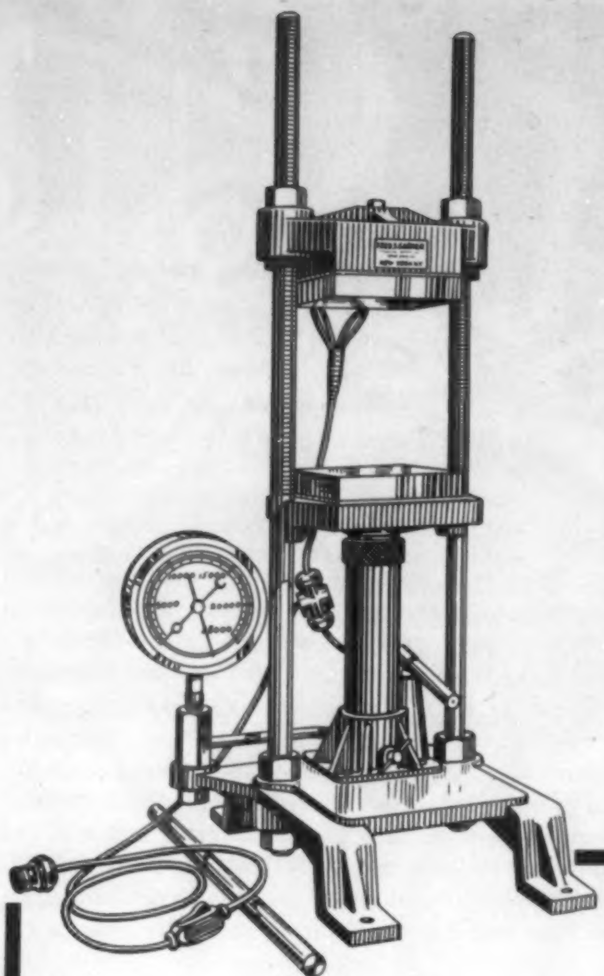
Uneven surfaces on the molded piece, shrinkage, cracking, and discoloration are but a few of the troubles caused by improper temperature. Therefore, the temperature of the mold cavity must be checked from time to time to make sure it is not too high nor too low for the material being run. Pyrometers, in a variety of sizes and shapes are available for this purpose. A new temperature controller, developed during the past year, which automatically maintains the temperature at the best operating point, is being used by a number of molding plants in connection with injection machines.

All the accessories the press operator needs to do his work accurately and well should be assembled on a wood or metal bench conveniently placed. The work table or bench should be designed to accommodate a supply of molding material, inserts, loading board, tote box for molded pieces, and miscellaneous tools such as hammers, plyers, tweezers, scrapers, etc. Cranes or overhead pulleys for inserting and removing large molds from the presses, and hand-operated arbor presses for separating dies wherever hand molds are being used, should be located nearby. Mold storage space is usually established in close proximity to the press room where dies, together with all the parts that go with them, can be cataloged and filed for future use.

Finishing department

Molded pieces are taken to the finishing department in the same trucks, conveyors or tote boxes used for supplying material to the presses. Here the light fin or over-flow incident to the molding operation is removed and the pieces are polished. Small parts, such as electrical plugs and attachments, bottle and tube caps, buttons, etc., are placed in revolving tumbling barrels and as the pieces brush against each other, the flash breaks off and drops through a screen in the barrel. Tumbled in a second barrel, together with shoe pegs, bits of leather, or other material, and a polishing compound, the pieces receive a lustrous finish.

Hand files, high-speed drill presses, punch presses, tapping machines, horizontal belt sanders, vertical belt sanders, riveting machines and planing lathes, in addition to specially designed machinery for specific operations, are used for cleaning and finishing large or irregu-



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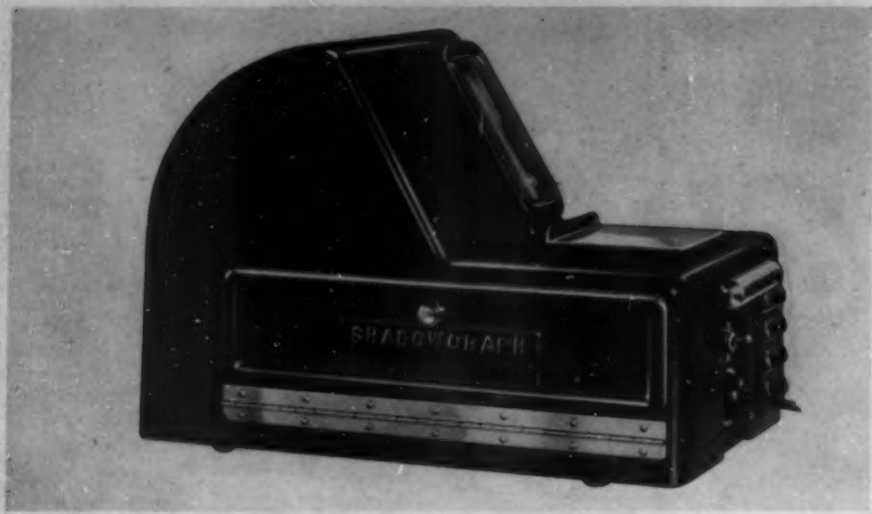

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Fig. 17—Here is a compact sensitive scale for precision weighing with all working parts enclosed to protect the delicate mechanism from dust and dirt. (Photo courtesy Exact Weight Scale Co.)

larly shaped parts. Polishing is usually accomplished with two buffing wheels, the first treated with a polishing compound, and the second dry. The finishing room should be equipped with compressed air lines for cleaning the various machines, and with exhaust hoods at every point where there is likely to be dust or dirt in the air.

Inspection and packing

A complete system of inspection is necessary to prevent imperfect pieces from being included in shipments to customers. Benches, fitted with a hopper and moving belt, may be used for examining small parts. The parts drop from the hopper onto the belt and pass along in front of inspectors who are so well trained that they can spot an irregularity at a glance. Large parts, or those to be incorporated with others into a finished object, oftentimes require precise gaging with micrometers, calipers, or blocks prepared especially for use with specific items. A fluoroscope is used in some shops for checking the location and condition of inserts or to reveal any interior flaws in the material. From time to time during the day's run, representative pieces produced by different presses must also be checked to catch any defect that may develop in the mold or to correct any timing deficiency.

As soon as the molded pieces have passed the inspectors, they are ready for packing. Some molders, who produce small articles in large quantities, use an electrically controlled vibratory feeder conveyor in connection with a scale for packing the proper number of parts in each carton. The carton is placed on a scale and when the proper weight is reached, an electric control on the scale cuts off the current to the feeder and the flow button closes. Ordinarily no special precautions need be taken to separate individual plastic parts. Careful packing, with a nominal amount of protection for large objects, is all that is required.

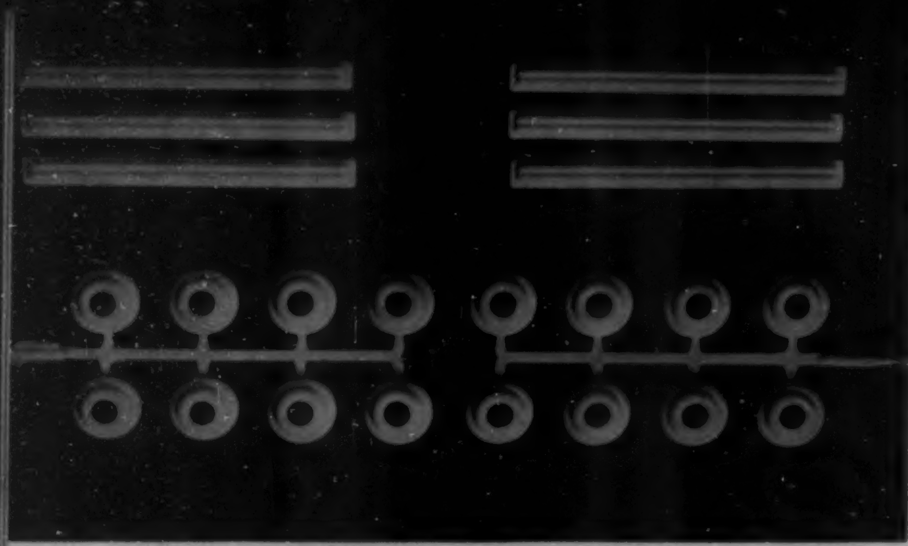
Machine shop

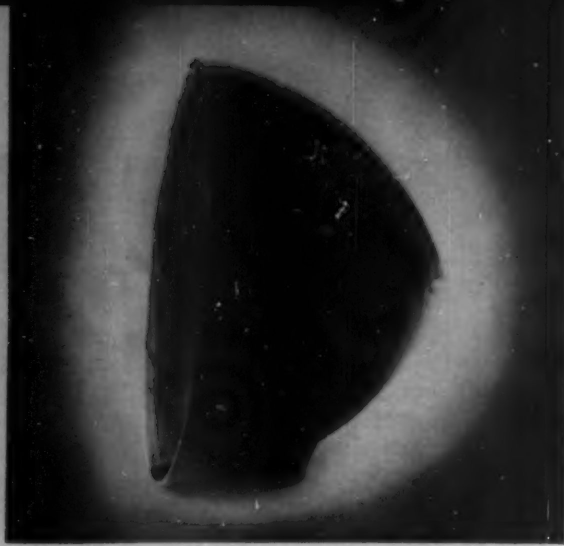
A machine shop with a complete assortment of lathes, milling machines, grinders, saws, punches, drills, etc., is necessary to the smooth functioning of any molding shop. Here cracked or damaged dies are repaired and repolished and machinery and tools throughout the shop are kept in good working order. Many of the larger outfits make their own dies and this necessitates a complete drafting and design department, steel storage section, and proper fabricating machinery and equipment. Mechanical saws, planers, shapers, milling and diesinking machines, grinding wheels, lathes and drills of all sizes are required to cut, grind, and shape solid blocks of steel into efficient molds. Hobbing presses and duplicating machines should be provided for economically reproducing identical cavities from master designs.

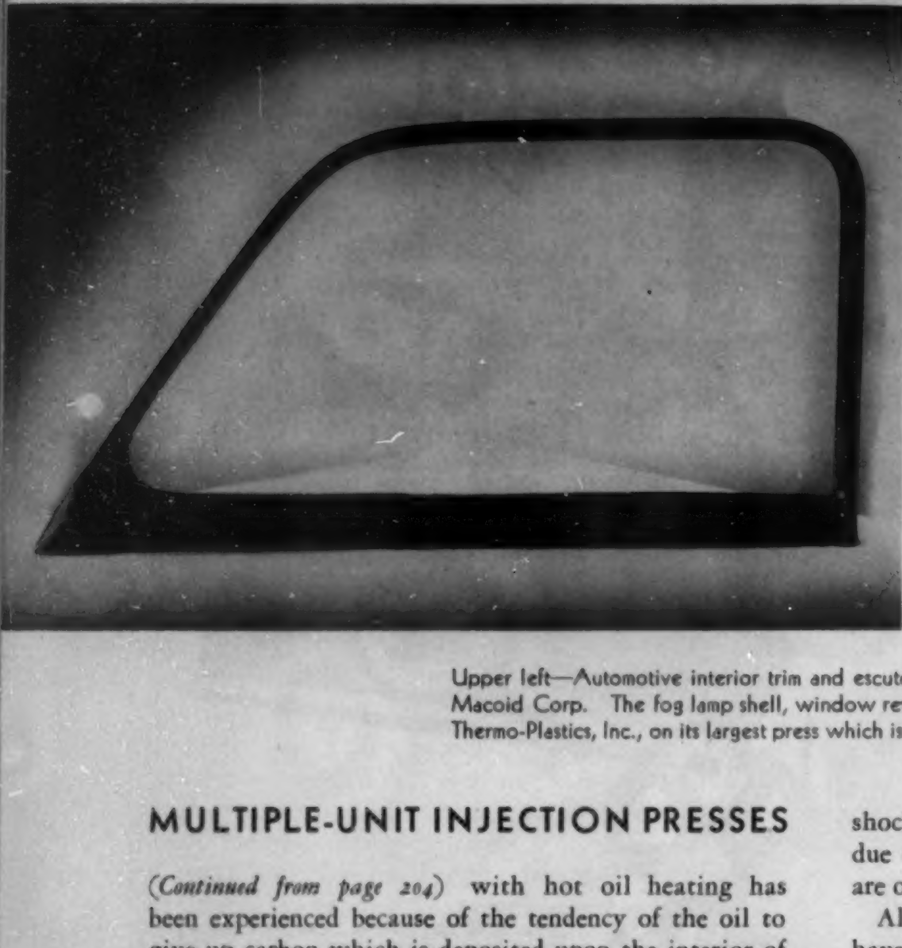
Lighting

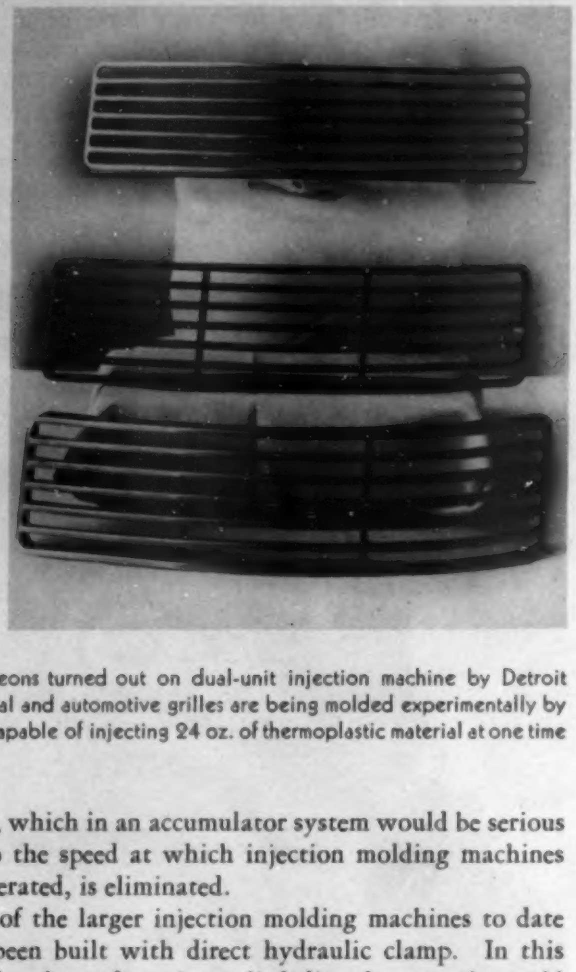
No matter how good natural lighting facilities may be, the average molding shop requires an efficient system of artificial lighting even in the daytime. Intensive overhead illumination may be sufficient in some sections of the shop, but at other points, individual lighting is necessary. For example, drop lights or flexible lamps should be arranged at each press so that the operator can see to properly clean the dies between cycles, and place inserts in position. One of the newest and most practical installations of lighting in a molding shop adopts a trolley duct system of wiring for general plant lighting. An overhead track contains fully insulated, 50 ampere copper bus bars with movable current-collecting trolleys to which luminaires are attached. The trolleys are inserted in the duct runs and can be moved easily to provide light at machines, presses, or wherever it is needed. A continuous outlet extending along one side of the duct sections makes it a simple matter to insert additional lights whenever it is necessary.

Comfortable working conditions should be maintained at all times, especially in the press room where the heat sometimes becomes intense. Electric fans or blower systems help to eliminate excessive heat here as well as in other sections of the shop. Rest rooms in many plants are equipped with showers and at least one molder has installed a swimming pool nearby where employees can take a dip during rest periods.









Upper left—Automotive interior trim and escutcheons turned out on dual-unit injection machine by Detroit Macoid Corp. The fog lamp shell, window reveal and automotive grilles are being molded experimentally by Thermo-Plastics, Inc., on its largest press which is capable of injecting 24 oz. of thermoplastic material at one time

MULTIPLE-UNIT INJECTION PRESSES

(*Continued from page 204*) with hot oil heating has been experienced because of the tendency of the oil to give up carbon which is deposited upon the interior of the heater and upon the heating elements. This trouble has been traced to high temperature at the surface of the heating elements and has been overcome by using elements of lower watt density.

Although conventional molding presses are frequently operated from accumulator systems, injection machines are almost without exception designed as independent self-contained units with fluid pressure pumps and motors mounted on the machines. There are a number of reasons for this. Accumulator systems in general are less popular since high speed variable output pumps have been developed so that their output volume and pressures are readily controlled and regulated to the varying requirements of the machine. Oil is used as an operating fluid, providing lubrication and practically eliminating packing troubles. Installation is greatly simplified and shock, which in an accumulator system would be serious due to the speed at which injection molding machines are operated, is eliminated.

All of the larger injection molding machines to date have been built with direct hydraulic clamp. In this way the clamp force is applied directly over the mold and is definitely known and under perfect control. Smooth movement, free from shock, is especially important where inserts are used.

The first large capacity vertical clamp injection molding press built had a plasticizing capacity of 8 ounces per unit, or 16 ounces total. Since then presses of similar type have been requested by plastic molders with double this injection capacity and 500 tons clamp pressure capacity, and this demand is being successfully met by the large capacity vertical clamp machines with their multiple injection units. It is difficult to predict what the future holds forth as far as capacities are concerned. We can rely only upon the splendid progress that has been made in such a short time with injection molding and its apparently unlimited possibilities.

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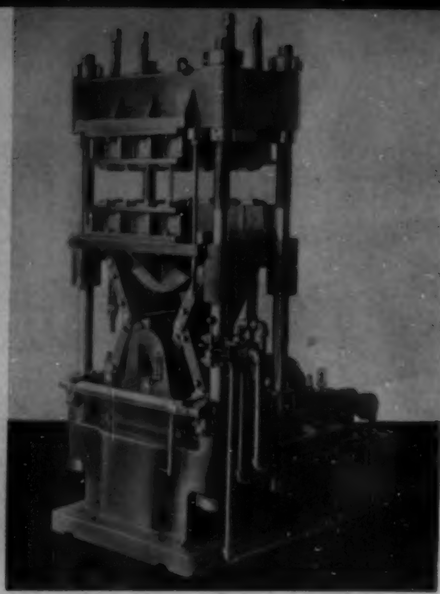

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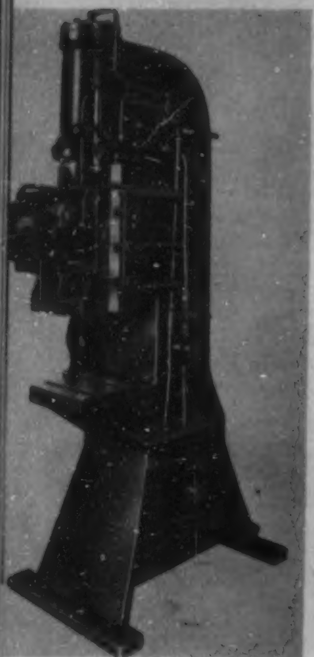

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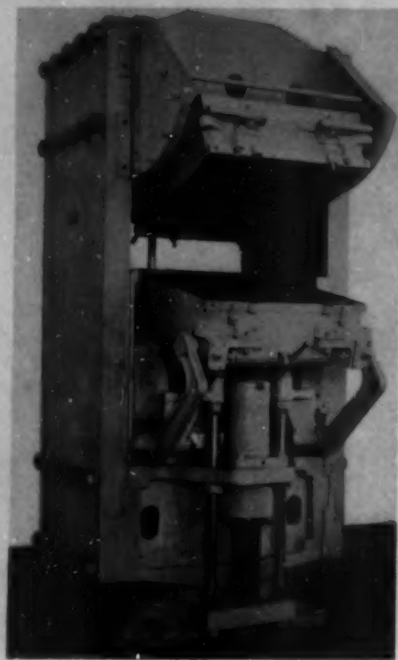

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Another group of specialized molding presses. Fig. 4—A broad-beamed self-contained press set up with a multi-cavity handset telephone mold which may be tilted for cleaning or placing of inserts. (Photo courtesy French Oil Mill Machinery Co.) Fig. 5—A 100-ton electric drive semi-automatic. (Photo courtesy F. J. Stokes Machine Co.) Fig. 6—Semi-automatic 60-ton self-contained job. (Photo courtesy Watson-Stillman Co.) Fig. 7—This arbor press while designed for laboratory work is adaptable for light production molding. (Photo courtesy Greenerd Arbor Press Co.) Fig. 8—Volume production of closures and similar small pieces is possible with this tilting-head press using multi-cavity molds. (Photo courtesy Lake Erie Eng. Corp.)

HYDRAULIC COMPRESSION PRESSES

(*Continued from page 178*) boards. One thing to remember about women operators is that they generally do what they're told. They're not likely to try to clean off a mold with a cold chisel."

"Here are two small parts that will run to approximately 1,200,000 a year each. Is that the spot for a semi-automatic press?" Brown handed us the prints on pieces Nos. 9 and 10.

"Yes, you will need a small semi-automatic for those." It looked as though the cycle on each would run to about $1\frac{1}{2}$ minutes. To be on the safe side we assumed a 2 minute cycle and filled in the production chart—except for the tonnage of the press.

"Due to the shape of these pieces," we stated, "the mold will permit the application of higher than average pressure. This means that you can use a stiffer, and therefore a faster curing, material." Eighteen cavities, at a little over .75 sq. in. in area each, came to 14 square inches total area. Stepping up the pressure to 3000 lbs. per sq. in. called for a press of 21 tons net. We put the figure on the chart and paused to answer a question about the term "semi-automatic."

"A press of this type," we explained, "has its molds fastened to the top and bottom platen. Ejector pins in either the top or bottom section of the mold, or in both, serve to push the pieces out of the mold. If mechanical ejectors are used they are actuated by the return stroke of the ram. This return stroke is generally effected by so-called pushback or pullback rams. The molds, which rest on the bolsters and parallels are directly heated either by steam, electricity or superheated water. With thermoplastic materials electricity cannot be used because the mold must be cooled before ejection of the piece and electricity does not provide for rapid reheating."

Piece No. 11 was a box-shaped article, 6 in. by 5 in. by 2 in. Brown said that the piece might have to stand a lot of rough usage. They wanted 550,000 a year.

"You ought to get a three minute cycle but we had better allow four. The chart then shows that a 4-cavity mold would have to run four years to give you the required production. So you will have to use 4 presses.

"Suppose we allow for 2 tons to the square inch, in case you decide on a stiff material. That would be 240 tons, plus, say, an additional 48 tons to allow for the 2 in. draw. The presses will be of 300 tons net with a generous allowance for pushbacks to open this type of mold. As for accumulator systems *versus* self-contained units, that all depends on the size of the installation, the amount of control desired and other factors. If you were planning to use but a few presses you might find it wise to make each one a self-contained unit. Each press would then have either a variable delivery centrifugal

pump or a two pressure unit, consisting of a low pressure large volume pump and a high pressure small volume pump. It could be fitted with automatic time-cycle control so that your operator could load the mold, press a button, and go on to another press. After a given interval the automatic control would open the press, possibly ringing a bell to inform him that the cycle was complete. However, you will appreciate that beyond a certain point it may not be advisable to equip a plant with individual pumping units for each press. In your case there are apparently too many presses planned to secure efficiency with anything but an accumulator system."

"We have some pieces here for which we plan to use the new crystal-clear thermoplastic resins," said Brown, "and the manufacturers advise compression molding to get optically clear pieces." He spread out the prints on pieces Nos. 12 and 13.

"It looks as though you get your self-contained units after all. This work seems to call for tilting head presses as self-contained units. With the material in question you cannot let your operator guess when the material has enough heat and pressure to form it properly. Nor will you wish to leave it in the mold to cool any longer than is necessary. Once you find the ideal time for each of these steps you can set your timer and have accurate control of the cycle."

"But why tilting head presses? I thought they were used principally for high production or for pieces requiring inserts."

"That's true enough, especially where a number of cavities are used." We picked up the blueprint on piece No. 15 and did some calculating. "Here, for instance, is a piece where the whole annual requirement of 10,000,000 pieces can be turned out by one man operating two tilting head presses fitted with 75 cavity molds.

"Getting back to these thermoplastic pieces, Nos. 12 and 13, you want to mold. Here is a case where the operator must be certain that there isn't the least bit of dirt or residue on either half of the mold before he reloads or the rejects will knock your hat off. Unless you plan to have him stand on his head to look at the forces on the top platen—as he would have to do on a straight S. A. press—you've got to bring those forces out into the open. You'll probably want to do this work in an air conditioned room—and as long as you have self-contained presses you can build this room wherever it is most convenient."

The blueprint on Piece No. 14 was a nightmare. "Now don't ask me can we eliminate the undercuts," said Brown, "because we've been all through that. That piece has to be molded as is. And we need about 12,000 a month."

"You will remember that only a few minutes ago we suggested hand molding for a piece not at all unlike this. But since your volume requirements are high in this case we are going to recommend an angle molding press. Aside from the increased speed, this press offers another advantage—lower finishing costs. Hand molds are naturally inclined to wear, eventually producing fins or other imperfections in the molded piece. In time the mold must be sent back to the shop for refinishing. Fitting the mold into the press reduces this wear and produces a piece that requires practically no finishing."

"I haven't the blueprints with me but we are thinking of molding some rather large pieces. One is over 1000 sq. in. in area. Do you think it will be possible to mold an item of this size?"

"That depends, of course, on the article in question. The trend in the plastics industry is towards larger presses and more ambitious moldings. Constant improvement in materials, molds and presses indicates that the surface of this phase of the molding industry has hardly been scratched. Apparently the only limitation on size is a matter of economics."

PRODUCTION CHART

BASED ON 8 HOUR DAY—200 HOURS PER MONTH

Piece No.	No. req'd per year	No. of cavities per mold	Cycles per hour	Est. hourly production per mold	No. of mold hrs. to complete order	No. of presses req'd	Type of press
1	5,000	2	12	24	209	*1	30 Ton Hand Molding
2	3,000	2	10	20	150	*1	30 Ton Hand Molding
3	1,500	1	6	6	250	*1	50 Ton Hand Molding
4	5,000	1	10	10	500	*1	50 Ton Hand Molding
5	3,600	2	12	24	150	*1	50 Ton Hand Molding
6	10,000	4	12	48	210	*1	50 Ton Hand Molding
7	5,000	3	12	36	140	*1	50 Ton Hand Molding
8	3,600	2	10	20	180	*1	30 Ton Hand Molding
9	1,200,000	18	30	540	2,222	1	21 Ton S. A.
10	1,200,000	18	30	540	2,222	1	21 Ton S. A.
11	550,000	4	15	60	9,167	4	300 Ton S. A.
12	560,000	20	12	240	2,334	1	110 Ton Tilting Head Self-Cont'd.
13	560,000	20	12	240	2,334	1	110 Ton Tilting Head Self-Cont'd.
14	144,000	5	12	60	2,400	1	125 Ton Angle Molding
15	10,000,000	75	30	2,250	4,444	2	110 Ton Tilting Head

* Indicates molds are to be interchanged to produce more than one type piece on press.

FINISHING PLASTIC PIECES

(*Continued from page 177*) wheel. For openings or corners difficult of access, hand filing is often necessary.

For rough finishing, no special fixtures are required, but if close tolerances must be maintained, a special fixture is sometimes used to prevent taking too much or too little material from the part.

If, on the other hand, the castings are small, in which the cost of individual handling would be excessive, rough finishing can be satisfactorily handled by tumbling. In the tumbling process, the pieces are placed in an octagonal or hexagonal tumbling barrel, horizontally mounted, which is rotated at speeds of 20 to 40 RPM, depending on the nature of the part. If the part has sharp fine edges, which are likely to chip, it is best to keep the speed closer to 20 RPM; otherwise, it may run closer to 40.

The rough finishing of phenolic and urea parts by the tumbling method requires from one to five minutes. For small phenolic castings, small wooden pegs or burnishing balls are mixed with the parts, to avoid damage to the castings and metal inserts. Removing the flash from acetate parts requires a longer cycle—from three to six hours—with the use of wooden pegs, oil and resins.

When the rough finishing operation has been completed, we are ready to proceed with any drilling or tapping operations which may be required. Here, in general, the methods of the metal working shop are followed. Usually drilling and tapping operations can be expedited by the use of multiple drilling machines, used in conjunction with suitable drill jigs.

Because of the physical properties of the plastic materials, however, drilling, tapping and counterboring all require special high speed tools. Tool manufacturers are constantly endeavoring to develop drills and taps even better suited for use with plastic materials.

It is important to note that in plastic materials, we must allow for shrinkage not encountered in metal. This means, of course, that taps must be oversize. The grinding of taps for plastic materials is a study in itself. For

Multiple spindle drilling and tapping machines (left) in the finishing department of Chicago Molded Products Corp. Where holes are required for assembly devices or inserts which cannot be molded in, they are drilled and tapped in this way. Finished parts must be closely checked for any variation of specifications. This is a hand operation (right) where gages, micrometers and oftimes specially designed devices are employed

the phenolic materials, for example, more chip clearance and a smaller amount of land should be allowed, than when grinding for metal work.

Practically all tapping of plastics should be done dry. In some instances, however, a tetrachloride solution, used sparingly as a means of cooling and lubricating, is advisable, although any lubricant has a tendency to clog the threaded sector. All holes to be tapped should have a countersunk area at the opening, to eliminate the possibility of chipping or defacing the surface of the part.

Following the drilling and the tapping operation, the next step as a rule is the buffing to produce the final finish desired. If parts are small ones, the buffing may well be accomplished with maximum economy by the tumbling process. In tumble buffing, the procedure is very similar to that already described for rough finishing, except that the cycle is considerably longer and often a wax lubricant is used in connection with pins and balls to give a high luster. For example, small phenolic or urea parts require a tumble buffing cycle of one and one-half to eight hours, depending upon the nature of the part and the degree of finish desired. Acetate parts require from four to ten hours in the barrel. If a very high luster is desired, a wax polish will give the desired results.

Where parts are tumbled for any length of time in a

closed cylinder, the heat thus generated may cause a clouding of the finish. To prevent and remedy this condition, screened sections can be inserted to dissipate the heat and overcome any clouding tendency.

For larger pieces, and for small parts requiring an extra fine finish, hand polishing and buffing are necessary. In this type of work there are three important factors:

1. Correct speed of lathe,
2. Correct type and size of wheel,
3. Correct type and grade of abrasive.

For most buffing in plastics, the use of a soft wheel is recommended. The desired softness can be obtained by several methods among which are the use of thick sections of sewed muslin, and the insertion of spacers between disks. Sewed muslin buffs, lubricated with emery cake or tripoli compound of high tallow or stearic acid content, give the best cutting action and keep the work cool. Muslin buffs, without sewing, but lubricated with tripoli or chrome compound, give a light cutting action. For urea materials, muslin buffs, either sewed or unsewed with white lime compound, are recommended. Flannel buffs are used only for removing excess lubricants and bringing out the high luster. For removing rough edges on parts of canvas base phenolic material, sewed muslin buffs, lubricated with emery cake, give excellent results.

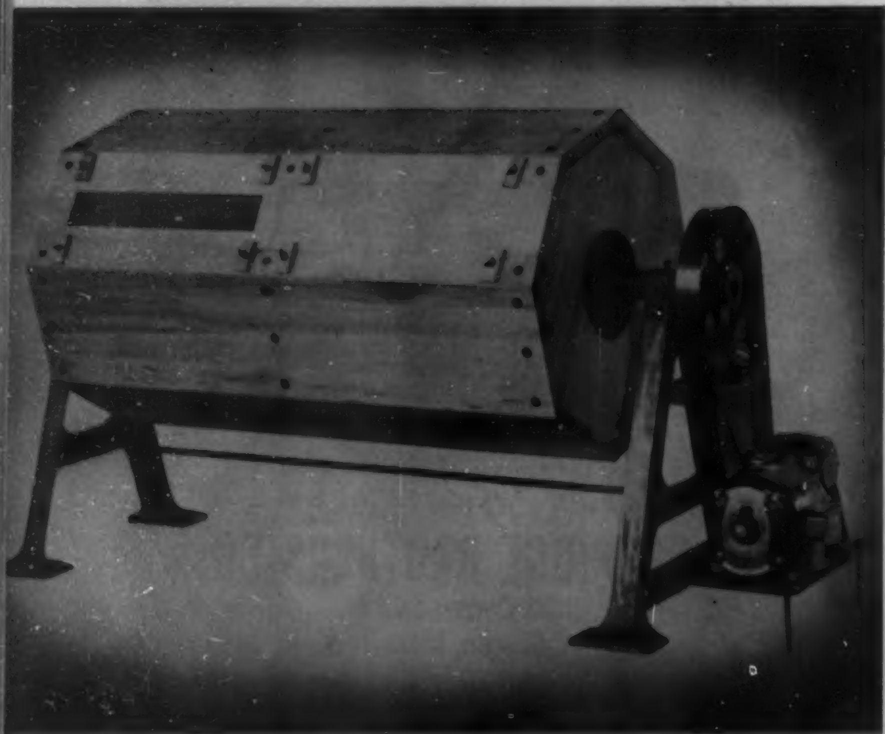
In connection with all polishing and buffing operations on phenolic pieces, it is important to keep this fact in mind: In the molding operation, a thin skin or coating of pure resin rises to the surface of the molded part, and this thin skin is capable of taking a higher, finer polish than can be imparted to the surface beneath. In many cases, it is impossible to avoid going below the skin surface, but wherever possible, buffing should be only deep enough to bring out the luster of the pure resin. In this way the best possible finish is obtained.

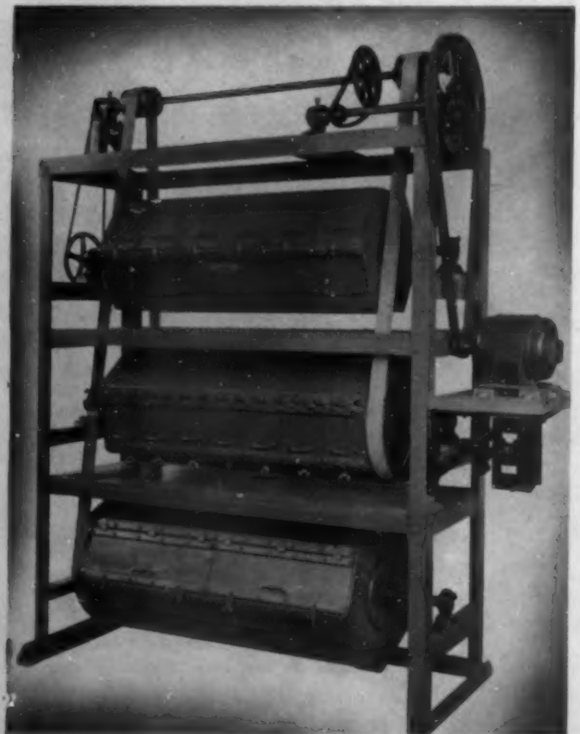
Even though lathes, wheels, and abrasives are selected with the greatest care, there is, in the final analysis, no substitute for individual experience and skill on the part of the operator. The friction and consequent heat which occurs when an object is held against a wheel revolving at high speed, may easily cause wavy, irregular surfaces, and the operator must know from long experience just how to prevent this condition. Some molded parts, such as clocks and radio dials, require that figures, lettering, or other decoration be filled in with a contrasting color of enamel or lacquer. This "filling in" is usually done by spraying or brushing, often in connection with special masks.

Usually, this filling would be the last operation before the final inspection, although sometimes it would be done just before buffing. In fact, the order of the final steps in finishing is always subject to some variation. Each job requires individual attention and the exact procedure must be worked out in accordance with the nature of the piece itself, and the set-up of the finishing room in which the work is to be done.

Inspection, as we have already noted, is more or less continuous throughout the finishing process. In all inspections, except those for quality of finish, gages are necessary. As a rule, two gages are employed—one for the plus and one for the minus limits.

Small plastic parts are usually finished in tumbling barrels where they are rolled with wooden pegs and wax. At the left is a large swing barrel unit with roller link chain motor connection made by Rudolph R. Siebert. At right, a three-tumbler unit by Lupomatic Tumbling Machine Company





AUTOMATIC MOLDING EQUIPMENT

(*Continued from page 176*) needed to permit the gases to escape, remaining in the breathing position the time required for the particular powder and section being molded, closes the mold again for the duration of the required curing period and then opens, ejects and discharges the molded piece while at the same time the mold cavity is cleaned. Each step in the molding-round and its duration is timed and controlled to a split second.

The semi-automatic press

Several hydraulic presses with semi-automatic control are now available. An interesting example is the combination hydraulic-toggle type press shown in Fig. 2. It is featured by its quick-action opening and closing and gradual slowing down as the mold closes. These desirable functions are obtained through the use of pneumatic valves controlled by a timer, and by the inherent design of the press itself, utilizing duplex pumps combined with the efficient toggle principle. Stroke and pressure are adjustable and other features are included that make for greater production and economy. They may be operated in batteries of four to six presses by girl operators. Controls are positive and simple and pressures are readily adjustable to the work in process. One distinct advantage of this type of press is the impossibility of overloading molds. When pressure is once set for a mold it is automatically maintained, and cannot be exceeded. This lessens wear and tear and effects substantial savings in mold costs.

Automatic molding upsets commonly held theories

The writer has had opportunity during the past few months to carry on some rather comprehensive experiments with a fully automatic molding machine. These have established a number of facts bearing directly on production costs and showing that with automatic equipment close uniformity in product quality can be attained at the same time mold productivity is increased and labor and operating costs are lowered.

It has been demonstrated that breathing is a most important factor in reducing molding time, that a single-cavity mold in an automatically timed cycle can produce as many as 60 or 70 or more moldings per hour, that a single kilowatt of power will heat the mold and operate the machine for 50 to 60 minutes. Production efficiency of this machine has proved remarkably high. Rejects are negligible. And the fact that records may be kept of the exact setting of the machine for each piece molded makes it possible to set up for the same job at some future time in about one hour's time.

Advantages of breathing

Experiments show conclusively that shorter cure, greatly to be desired in all molding operations, can be attained without sacrifice of product quality, by proper breathing of the mold and by allowing only the permissible minimum time for each step in the round. The ultimate maximum saving in this item is obtained because each step in each round can be set within a split second of the safe minimum time and this timing will repeat exactly for an indefinite number of times. By timing the breathing at the most advantageous point and for proper duration the saving, in some cases, amounts to as much as half or even more of the otherwise required curing time—and a perfectly homogeneous and finish-cured article is obtained. "Cheating" on the curing time or the breathing time, or both, results in an inferior article if not a defective one. Imperfections caused by under-curing or improper breathing may be detected by a visual inspection providing a blister shows up. On the other hand, improper breathing may be hidden by sufficiently extending the curing time so as to lock the compressed gases within the set wall sections. Such a section is radically weakened, although it cannot be detected from the outside.

Various methods for testing for proper cure are in use and the piece examined can be satisfactorily proved perfect or imperfect as the case may be. The discouraging feature about all tests, when manual control of the molding cycle is depended upon, is that no assurance can be had that each step in the cycle, or even each cycle, will be exactly the same. The piece examined may be a perfect one and still, by some undetectable variation of a few seconds at some step in the cycle, the next one may

3

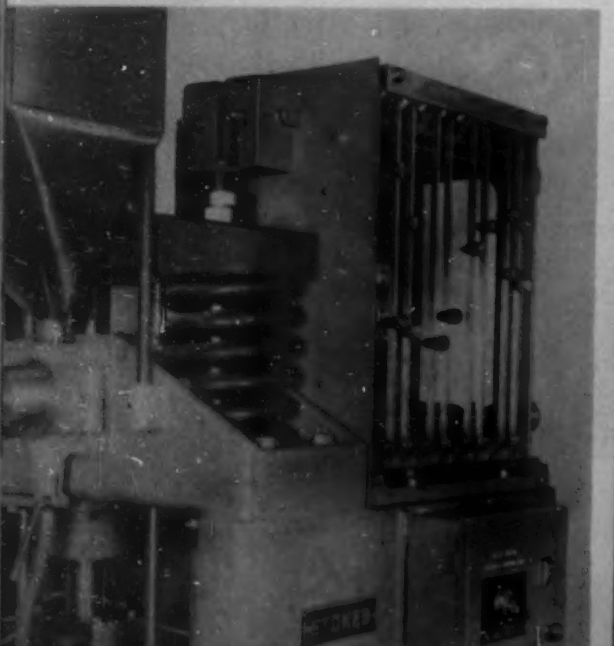


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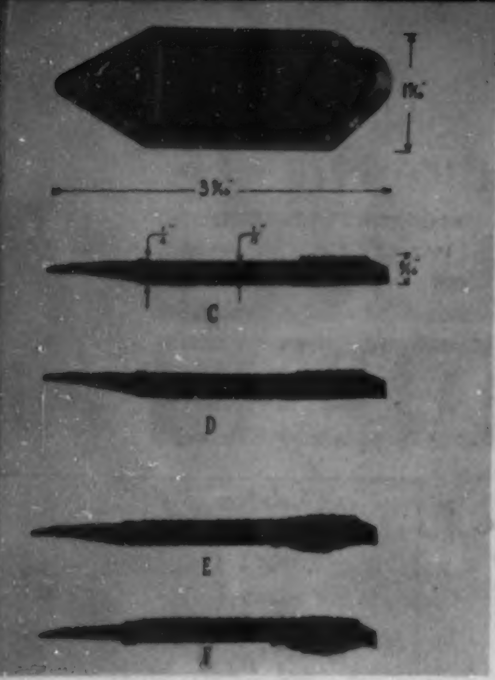
Fig. 3—Close-up of control device for timing cycle of operation on the Stokes automatic molding machine. Fig. 4—When molding cycle is completed, molding is lifted by knock-out pins and ejected by compressed air



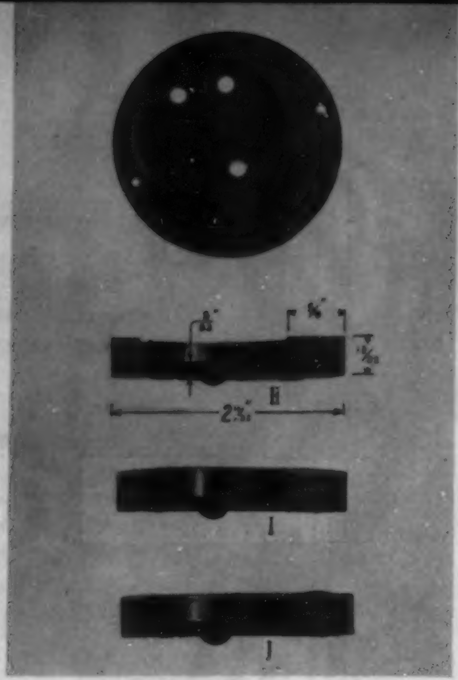


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Fig. 6—Souvenir-Scale, molded automatically, showing effects of proper and improper breathing. (See data in Fig. 5, below.) Fig. 7—Fishing reel, molded automatically. Note thick and thin sections and refer to data in Fig. 5 for timing cycle

be imperfect. With automatic molding, parts are always uniform because the machine repeats its exactly timed cycle an indefinite number of times.

Recording data

A form used by the writer for recording data is shown in Fig. 5. Here the time for each important step in the molding cycle is recorded together with various other data of interest to the estimating or production department. "Case History" records can also be made while molding sample lots, to cover each of the molding compounds used in making up samples. They will then furnish a very helpful record for comparison when selecting the most economical molding material that can be used in the efficient production of the piece.

Note the time for the round in molding the piece shown in Fig. 6, and how this is subdivided. To open the mold, eject the piece, clean the cavity, feed the required new charge of powder and close the mold again took 22 seconds. This time naturally will vary to suit the piece molded. For a thin piece a shallow mold-cavity would be used and the time required in opening the mold therefore is proportionately shorter than for a piece molded in a deep cavity. To save time here the

Fig. 5. Comparison of molding data for pieces shown in figures 6 and 7

Record No.	Figure.	Molding Material	Plasticity	Opening and Closing	Heating to Plastic	Breathing	Curing	Total Time for Round.
1	6	A-1	H	22 sec.	12 sec.	11 sec.	55 sec.	1 min. 40 sec.
2	6	A-2	H-	22 sec.	16 sec.	4 sec.	1 min. 3 sec.	1 min. 45 sec.
3	6	A-3	H-	22 sec.	8 sec.	4 sec.	21 sec.	55 sec.
4	7	A-4	H-	23 sec.	18 sec.	3 sec.	2 min. 11 sec.	2 min. 55 sec.
5	7	A-2	S	23 sec.	10 sec.	3 sec.	1 min. 34 sec.	2 min. 10 sec.
6	7	A-2	S	23 sec.	no	no	3 min. 32 sec.	3 min. 55 sec.

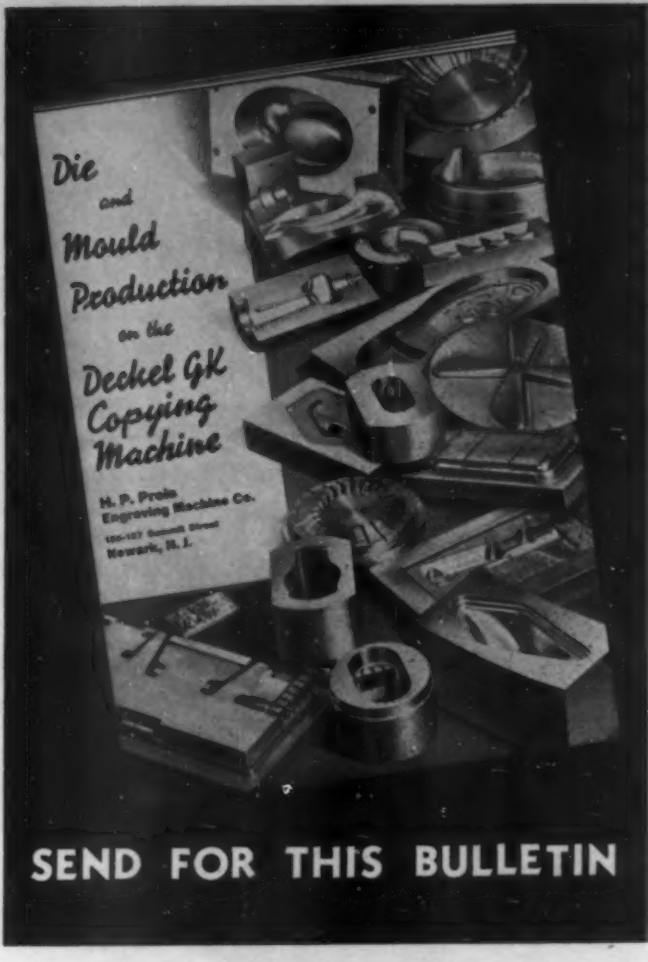
stroke of the ram is set to the minimum needed for ejecting the piece and feeding the powder into the cavity. A second or two in over-travel used up by the ram when opening the mold means an equal number of seconds wasted in going back to close the mold. Every second is worth saving. The remaining three items in the cycle will vary according to the type of molding-powder used, thickness of wall sections, unsupported area of the thin sections, number and location of knock-out-pins, etc.

The data in this table was taken from actual "Case Histories" covering the two pieces shown in Figs. 6 and 7, as molded from several different types of material.

Lines 4 to 6 in this table give data for the fishing reel of Fig. 7. Here another interesting fact is brought out. Line 5 shows that after heating the molding material for 10 sec. the mold was opened and kept open for 3 sec. to permit the gases to escape; then closed for 1 min. 34 sec. to cure, giving 2 min. and 10 seconds total time for the round. On line 6, corresponding data is given for that piece as molded from the same material and at the same temperature but with the breathing step omitted. Note that in this case it required a total time of 3 min. 55 sec. or 80 percent longer to obtain a piece that from the outside appeared perfect—no blisters. Although this last mentioned piece may have been perfectly satisfactory for its purpose, it could hardly be called perfect. When cut apart through the heavy section a number of minute pores could be detected by means of a magnifying glass.

In Fig. 6 are shown some sections of the Souvenir-Scale molded as per records in Fig. 5. As near as can be judged by the aid of a magnifying glass, the section at *C* is perfect. No porosity can be detected.

Cutting down 5 seconds on the time allowed for plasticizing before breathing, but keeping the curing time the same as before, the section shown at *D* is obtained. Judging from the outside appearance the piece is perfect, but cut the molded piece apart and it is found that the heavy section has several small gas pockets visible to the naked eye. Through a magnifying glass this section looks very bad—the whole central area around the larger pocket is a network of very small gas pockets. Indica-



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tions are that the time allowed for plasticizing was insufficient for the complete generation of all the gaseous matter. Probably a corresponding increase in breathing time, an extension of 5 to 10 seconds, would have permitted the slower forming gases also to escape.

The section shown at *E* was molded without breathing and the mold was opened 15 seconds earlier so that the walls would not have a chance to set very hard. A sharp crack like a shot was heard just as the mold had opened about $^1/_8$ in. and when the piece was cut apart the ugly gas pocket with a porous area all around it was found. Large blisters, of course, appeared on both sides of the piece.

The section *F* is from a piece molded from a colored material. Here the ugly gas pocket with the porous section around it shows even more clearly. When molding this piece no change in the total time of the round was made. The breathing step, however, was omitted and the results appear to be practically the same as for the piece shown at *E*.

The fishing-reel side shown in Fig. 7 has quite a heavy section extending along part of the rim. If this section had been lightened, by means of a few small holes part way through, the piece could have been molded in 20 to 30 seconds shorter time. With vent holes in this section it would also have been possible to mold this piece from several different types of material in two minutes or less. Actually only one out of half a dozen materials tried would produce a perfect piece in 2 min. 10 sec. It may not be out of place to call attention here to the importance in designing a piece to try to keep all sections of uniform cross sectional area. In many cases the time for molding can be materially reduced just by adding a few vent holes. This, of course, cannot always be done because it may spoil appearance, but often holes can be placed so that they are hidden when the piece is assembled with other parts.

Referring to sections *I* and *J:* These were molded in the same time but in 15 seconds shorter time than the section at *H*. It was difficult to discover from the outside that the section at *I* was defective. Only by placing a straight-edge across the surface could the slight blistering be seen, but when cut apart the bad condition of the interior was revealed. These two sections were selected only to show how easily one might be deceived by the outward apparently perfect appearance of one piece molded in a cycle a little short of that necessary for a sound job. With an indicator as that of section *J*, no one would have any difficulty in picking the rejects. There may be several explanations why the two sections molded in the same time appeared different. One reason might be that in the case of *I* some of the gases escaped with the flash or through some suitable break in the flash-seal at a critical point while in the case of *J* all the gases were positively locked in. The solution of the trouble, of course, is proper breathing, at the proper time in the cycle and for the required length of time. The above examples were selected for the purpose of pointing out the feasibility of obtaining definite molding data on molding jobs and how such data can be of valuable aid in lowering molding costs.

Selecting material

It is interesting to note that the Souvenir-Scale in Fig. 6, according to the record on line 3, was molded from one type of material in 55 seconds while with the other two materials recorded on the first and second lines it required 1 min. 40 sec. and 1 min. 45 sec., respectively, or 45 and 50 seconds longer to the round. With data of this kind before him, the molder should have no difficulty in picking preferred material. If cost of material and quality of the molding produced was satisfactory one need have no doubts as to which material to use.

Rejects

There should be no rejects unless one or two pieces are molded short because the feed hopper is empty. Of course there might be mishaps in the mold used in an automatic machine just the same as in any other molding machine. Such, for example, as some molding material caking fast to a cavity of the mold or breaking loose around some of the lettering or engraving. Such accidents will occur occasionally and perhaps particularly so until the mold is well broken in or if it is run too long without proper waxing.

While talking about production, time limits, rejects, etc., it is interesting to note the effect that slight changes in molding time have on the molded piece. How long a time is 5 seconds? How closely can the length of 10 seconds be judged without the aid of a stop-watch? Five seconds cut from the molding time may result in a defective and rejected piece as indicated by study of the two pieces shown in Figs. 6 and 7. Time available when this study was made did not permit the extensive experiment needed for obtaining various additional data which may have shed more light on this interesting problem.

ASSEMBLY ACCESSORIES

(*Continued from page 175*) sizes fit 80 percent of all screws commonly used.

Self-tapping screws made with the recessed tapered head, provide even further economy because power bits can be used to accomplish the fastening operation, speeding up the work of assembling various sections.

Speed nuts and speed clips

Another device now available for assembling plastic parts is a speed nut, made of spring steel, stainless steel, or phosphor-bronze, which holds with a firm spring tension grip. Originally developed for fastening handles on gas and electric ranges in place of lock washers and common nuts which were never entirely satisfactory, these have been used extensively on automobile assembly lines, and in the refrigerator and radio industries. Recently they have been found to make possible more rapid and economical plastic assemblies.

With these fastenings, no threads are necessary. The nuts are simply snapped over an integrally molded plastic stud or other molded part. Once in place, they provide strong holding power, for as strain, twist, or pull incidental to service becomes more severe, the fastening grips ever more tightly to the plastic stud or part. One form of nut applied to a round stud, makes a permanent fastening while another used over a D-shaped stud may be removed by a quarter turn and replaced as easily whenever the piece is taken apart and put together again.

Speed nuts are light in weight and can be zipped into corners and other hard-to-get-at places where almost any kind of fastening is difficult to use. They are manufactured in innumerable shapes and sizes—round, rectangular, U-shaped, L-shaped, etc.—to cover all phases of assembly requirements. Some are made in multiple units so as to engage two or more plastic studs at one time for quick assembly. In addition, special shapes and designs can be produced for specific jobs.

The speed clip, easily adaptable to almost any size or shape of plastic knob, is a spring tension compression ring that makes the knob "jump" into place in the assembly in a fraction of the time that would be required to screw it in. By this method, all inserts are eliminated as well as the webbing ordinarily used to reinforce the hub. The hub, which can be constructed safely with thinner walls, is molded with slots down two sides and may have a D-shaped opening to accept a D-shaped shaft or a round opening for a round shaft with plain or knurled end. The speed clip is snapped over the slotted hub with a special tool developed for the purpose. The simple external pressure of this spring tension compression ring helps confine the plastic molding to its original shape.

Metal chain

Practically all of present-day electric light sockets are equipped with metal chain pulls that are usually inserted into a molded or drilled hole in the finished plastic piece. This same type of chain may also be cemented or riveted into other plastic parts where it serves a definite purpose. A good example is its use on the molded head of the Sparklets soda syphon. Here, the chain is attached to the removable cap to keep it from becoming mislaid or lost when the syphon is being used. Since the chain is light in weight and flexible as well as neat in appearance, it makes a decorative and useful assembly means.

With larger and larger moldings being turned out, the need for speedier, more accurate and less costly fastening methods is constantly being met by the development of such improved assembly accessories. The devices mentioned are simple to use and save a great deal of time and labor, both in the molding operation and in assembling the finished parts.

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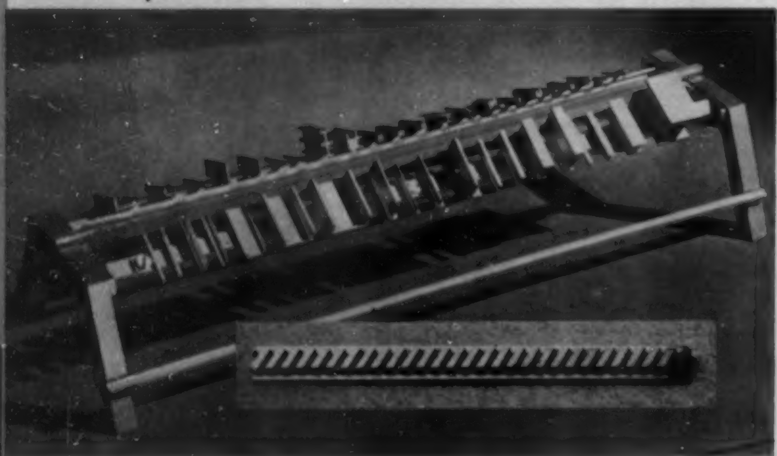

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Precision Shapes, Inc., provides a variety of metal inserts (Fig. 7) which are useful in strengthening and decorating plastic moldings. They are extruded in continuous lengths, cut at will. Fig. 8 shows the Parker-Kalon "U" type self-tapping screw used in attaching small contacts to microphone case

(*Continued from page 212*) table, usually 16 to 25 sets of punches and dies to each machine—the smaller press using 16 while the heavier size uses 25 sets. The proper weight is made by filling the die cavity and scraping off excess material before compressing. The preforms are made by a simultaneous slow squeeze on both top and bottom which gives a uniformly hard pill. The accuracy in pill weight is very good from this type of machine, and by using a slightly beveled edge on the pill, chipping the edges while handling is prevented, thus enabling further control on weight of preforms going into the molding operation.

While both types are indispensable in a modern molding plant, jobs that can be run with pellets from a rotary press have the advantage of a saving in direct costs.

At this point perhaps it would be well to emphasize the importance of care that should be given the punches and dies which shape the pellets. While the rotary punches and dies will show less wear over a long period than the punches and dies on the reciprocating press, they both need careful checking at frequent intervals to insure maximum life of these parts. Unnecessarily hard pills, improper greasing or oiling, wrong clearance and relief on punches, all contribute to the cause of costly production delays. When the single punch jobs are finished, dies should be gone over and if any jams appear on the edges, caused by the top punch becoming loose in die holder while in operation, they should be smoothed up, so they will be ready when needed again.

New machines have been recently designed solely for the plastics industry and deliver truly marvelous work. In the olden days when the industry was getting its start, damages by over-loads, jamming, sticking, were every day occurrences. All this has been eliminated, and with the advantages of quicker die change and easier cleaning, speed and flexibility of production has been increased.

Irregularities in preform weights, assuming a properly blended compound is used, can generally be traced to improper adjustments of feed frames, shaker shoes and hoppers. The feed frames on the rotary type should have at least $^1/_{64}$ in. clearance above the revolving table.

The shaker shoe on the single type press has, at several points of its length, a direct bearing surface on the table of the machine. This is essential, due to its function of scraping excess material from the top of the die cavity. The point to be considered is to have this bearing surface exactly level—this will serve doubly, preventing excessive spill over side of machine and scraping the proper amount of material each time it travels across the die.

Plastics now available are many and varied, but they have been developed and perfected so that difficulties seldom arise that would cause poor preforming conditions. The varied shapes that can be made sometimes turns an impossible or impractical job into one that becomes merely another routine molding operation. Preforming today is the most economical method of handling molding compounds and pays its dividends in reduced waste and finer finished pieces.

(*Continued from page 208*) of air exhausted is controlled by an adjustable damper system.

The temperature control on this new preheating oven is entirely automatic and unusually accurate. It permits the operator to predetermine the heat that is best for preheating, to set the controller for that heat and to go about his other work feeling confident that when the time arrives to take the preforms or powders from the oven, they will be just right for molding. The usual temperature range is from 125 to 300 deg. F. (51.5 to 149 C.). Special ranges for higher temperatures are also available if desired. The combination of uniformity of temperature throughout the working chamber and the assurance of positive and accurate temperature control is certain to give the desired preheating results without danger of over or under heating.

Preheating ovens may be provided with swing doors, lift doors, flap doors, or with drawers. Most molders prefer the drawer arrangement as the drawers can be constructed so that when they are in the *out* position the oven may be sealed. This permits continuous loading and unloading without materially affecting the interior oven temperature. By a series of drawers, determined by time required for preheating and production required, the proper cycle may be established.

Steam, electricity, or gas may be used for heating the new mechanical convection oven. This permits the molder to study the costs of the various fuels and to select the unit which best serves him. As far as the initial investment is concerned, the gas heated oven is the least expensive and the steam is the most expensive, although the difference between gas and steam ovens is only a small amount. Mechanical convection ovens, (using fan and motor equipment) are not expensive and are considered a good investment because the increased production and better results usually pay the investment cost in just a few months' time. The operating costs are practically negligible. Reports vary in different localities from 1 cent to $4^1/_2$ cents per hour.

There is another type of preheating oven known as a gravity convected type. It has no fan or motor equipment and depends upon the difference in the weight of the heated air for the circulation. These units are less expensive, but have the disadvantages that the heat transfer rate is slow, and greater care must be taken in loading drawers or shelves so as not to block vertical air travel. A larger gravity type oven is required for a given production capacity and as space is often at a premium, this design is not always practical.

Although molding methods have advanced greatly, there are still many things to be developed. There will be many contributions which will assist the industry to make continued rapid progress. The new preheating oven is one valuable contribution. It supplies the long-felt need for equipment for "proper preform and powder preheating." Similar equipment is being used for aging, curing, and normalizing, but this will be taken up at some later date.

MOLD DESIGN AND CONSTRUCTION

(*Continued from page 194*) must be taken not to have oxygen come in contact with the heated steel, especially when transferring the hob from the furnace to the quenching bath. When using oven heating furnace it helps to pack the hob in charcoal or prepared carburizing compound, using open box or can so all the working part of the hob is covered. This insures protection from oxidization and scaling. When transferring the hob from the box or can to the quenching bath, the working part of the hob can be dipped in casenit or cyanide; this further insures extreme hard surface of the hob.

When preparing hobbing blanks it is not advisable to use too large a blank, especially on jobs with side steps or knurls. Having too much iron on the sides causes iron to flow away from the hob, and consequently produces undercuts in the cavities. On shallow cavities the undercuts are closed successfully with the closing steps on the hob. Deep cavities require even greater care.

Where hobbing blanks must be relieved, it is often advisable to make provisions in the hobbing chase ring for iron to flow in. This method is mostly practical where side pieces are used in a round chase ring for rectangular cavities. These side pieces are cut away at the bottom, allowing necessary space for flow of iron, according to the displacement of the hob. This method is efficient when large quantities of cavities are being made, because it eliminates the machining operation of relieving the blanks, and produces uniform cavities.

Carbonization test

Depth of carbonization in pack-hardening iron or low carbon steel for mold cavities and force plugs is of the utmost importance. In many instances Brinell or Rockwell tests may show sufficient hardness. However on these same pieces the depth of carbonization may not be any more than .035 in. When the mold is put in production it does not take long before the mold surface begins to sink. It has been found that the most satisfactory pack-hardening for molds is when the depth of carbon is from .060 in. to .090 in. When carburizing mold parts it is advisable to pack at the same time a piece of the same metal about $^3/_8$ in. round or square. When the hardening is completed, this piece can be broken and the depth of carbon penetration can be checked or seen. On most of the carburized mold parts the tempering of 375 deg. to 450 deg. F. is satisfactory. However if there are thin sections in the cavities or force plugs, this tempering is not sufficient because it leaves the thin section too brittle. Thin sections are satisfactorily tempered with fine direct flame to blue color. This method is rapid and it can be done without drawing the temper any more than 450 deg. F. on the balance of the part.

All of these points must be given full consideration in the building of molds for phenolic materials, and not until they are carefully considered can the best results be obtained and the desirable qualities of the material involved be brought forth in the finished piece.

LABORATORY PRESSES

(*Continued from page 180*) his production schedule to test every changed material which comes along but if the experimental mold is employed for this purpose he may secure a faster cure or a better molded piece. The laboratory press has much to recommend it besides its ability to determine conditions of temperature and pressure in molding, laminating, vulcanizing and extrusion more efficiently than a large press. One of the largest molders in the country, having a number of plants and laboratories, uses nine of these small laboratory presses.

A manufacturer of office supplies recently desired to convert one of his items to plastics. Of two suggested designs he could not be certain which one would have the greater sales appeal so he purchased a laboratory press and had two single cavity molds built. Inside of two weeks, and at an expenditure of approximately $350, he had a miniature molding plant. (Fig. 2.) Not only that, but each of his salesmen had two different sample pieces. One of them—the one he preferred—was found to have only 10 percent of the appeal of the other. Not only did he avoid a loss on an expensive mold but by the time his production mold was ready he had on hand enough orders to keep it going for three months.

A new type of press for molding closures was recently invented. Although it looked good "on paper" its operating principle was new and untried. To prove the device the inventor had a special head built for his 10-ton laboratory press and fitted it with a 9 cavity mold. (Fig. 3.) Except for the substitution of springs for the hydraulic rams that would act as pushbacks and operate a floating chase he had an exact duplicate of the proposed high production press at a fraction of the cost. In the shortest possible time he was able to demonstrate that the invention was practical. Among other things, he wished to investigate the possibility of carrying off ejected pieces and removing their flash in an air conveyor. This test required a number of pieces so he put the press to work. In less than 8 hours he had 1000 molded pieces! And all this, without going outside the laboratory.

Laboratory presses are made also by Chas. E. Elmes Engineering Works. The one pictured has a maximum opening of 16 in. with platen bearing surfaces 8 in. square. They operate from an ordinary electric light socket and develop pressures from 12 to 20 tons

PAGES 259 TO 278

LAMINATES

HOW LAMINATES ARE MADE

by GEORGE H. CLARK

GENERALLY SPEAKING, ALL DECORATIVE LAMinated plastics are made from heat curing resins combined with fibrous sheets such as paper, the combination of paper and resin being consolidated into sheet form by the application of heat and pressure. Variations exist, of course, and canvas, thin metal and real wood are often incorporated in the process as will be explained. The resin comes to us in the form of varnish, it being a solution of the resinous material in solvents such as alcohol or water. The fact that many interesting resins highly successful in molded form are not soluble into varnish limits the laminated field largely to phenol and urea-formaldehydes; the first soluble in alcohol and the second in water.

If paper is dipped in these varnishes and then subjected to moderate heat the solvents pass off as vapor leaving the paper impregnated with essentially dry resin. The process is not quite as simple as it sounds because many manufacturing complications develop. It is possible to make sheets of pure resin but they have no commercial value because they are too brittle to handle, much less to use. The paper serves two purposes then, first to add the strength and flexibility factors to the finished product and second, to prevent the resin impregnated in the paper from squirting out of the press as it passes through the liquid stage under heat.

Mixing room

In the fundamental process of making phenolic varnish, the material before it is complete is dissolved in alcohol. If the distilling process is carried on, it would result in a mass of resin which for the molding industry is ground into powder or small crystals. For laminating, however, the material is caught just before it solidifies, is dissolved in alcohol and delivered as varnish. The varnish is too heavy to use for laminating in this form so it is run into a kettle and enough additional solvent is mixed with it to obtain the desired consistency.

Urea, which is delivered in stainless steel barrels, is dissolved in a water solution and looks clear with a slightly milky tinge. Thiourea is used for laminating although it has disadvantages in the sense that it isn't as water resistant as straight urea and doesn't cure at as favorable temperatures. However, it can be laminated and straight urea cannot.

Paper

Papers vary for different purposes in both decorative and industrial laminated and cost anywhere from five cents up to twenty-three or twenty-four cents a pound. Almost every type of paper is used in one way or another, both cellulose and krafts, and some straight rag papers are used where strength is important.

Impregnating

Although vertical impregnating machines are successfully operated in some plants, we use horizontal treating or impregnating machines. A roll of paper is placed beneath the front end of the machine on a mandrel. As it unwinds, the paper passes over a roll, dips down into the varnish solution, continues up over another roll where a plate scrapes off excess varnish, then the paper disappears into the machine. The interior of the machine is fitted with steam coils and as the paper runs through, the heat throws off the alcohol in the varnish and dries the paper to the proper degree. As the paper leaves this oven and is wound on a convenient mandrel, it has a resin content varying from 20 percent to 70 or 80 percent depending upon the kind of material that is being made. The volatile content might be only 2 to 5 percent if the material were all dried out, but material so thoroughly cured would be extremely brittle and could not be rolled up. It would be so dry that the varnish would not flow when the sheets were put in the press and so, would not make a good laminated sheet. Therefore, some solvent is left in and when the sheet reaches the press this allows the resin to flow and consolidate into the sheet. Part of the volatile is recovered and used in subsequent batches of varnish. Some still remains in the sheet when it is finished.

Cloth is used as a base for industrial applications and this is put through an oven that differs in only one respect from the one described. The difference is that the volatile solvent, driven off by the heat, is condensed in the bottom of the oven, to be recovered and used over again. Naturally, with a material like cloth, where the resin content is heavy, more solvent is used and it is an economic necessity to recover it rather than let it evaporate in thin air. Therefore, the oven in which cloth is treated, heats in the top section, condenses in the lower

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section and the solvent runs to the back of the machine where it is recovered to be re-distilled and used again.

Color

To provide a colored surface in the finished sheet, a pigment coat is put on the color sheet in a similar type of horizontal machine. The coloring consists of a mixture of suitable pigments in urea varnish. Paper previously treated with urea varnish to give it strength is dipped in the solution, coated on but one side and passed through the oven for drying. The material then has a urea back and urea color on top. From an economic standpoint, urea is a good material to use because its solvent is water which costs little.

Printed designs

Patterned laminated material is secured by offset printing. Designs are etched on the surface of a continuous copper plate wound around a cylinder which contacts the inked printing roll and subsequently transfers the design on the paper. It required years to work out suitable inks to do this job because there must be nothing in them that is foreign to the consolidation process. No laminated material is printed with ordinary types of lithographing inks. The printing rolls themselves had to be specially developed for this purpose. Printers use gelatin rolls but these are not practical for laminated printing since the urea inks are water soluble.

Inlays

Many table tops, doors, panels, counter fronts and tops and other decorative or architectural applications are inlayed with metal strips or contrasting colors of other laminated materials. These strips, or any inlays, are laid on the surface to form the desired pattern and then are actually pressed down into the sheet to a point where they are absolutely level with the surface. Two or more colors may be introduced into the decoration and many variations are possible. Lettering may be easily incorporated into the design but complicated patterns are inclined to boost the cost.

Assembly for pressing

All these steps are preliminary to the actual laminating process. Each careful step of preparing the sheets is carried on separately in various departments, then they are finally brought to the assembly room where they are collated for pressing.

The surface of the laminated sheet is determined by a steel plate which for a glossy finish has a mirror surface. For a satin finish, a satin-surfaced plate is used. Likewise, Morocco and other leather finishes are obtained from a steel plate in which this finish has been carefully engraved. There must be no pits, dents, scratches or anything else in these plates, for the least little scratch will show up in the material. Even the most minute defect on the plate will repeat itself in the laminated surface. The finish obtained can only be as good as the plate from which it is pressed.

In building up a laminated sheet, a translucent urea sheet is placed against the finish plate, followed by a printed sheet which has its decoration on the front. Next comes the color background sheet, blister-proof sheet (if one is being used), filler stock and the backing sheet. If a plain colored sheet is desired, then the printed sheet is omitted. If real wood is being laminated, the impregnated veneer supplants both the printed and color background sheets.

When all this is pressed together it results in a $^1/_{16}$ in. sheet of finished material. Two sheets may be built back to back with no plate between to get two $^1/_{16}$ in. sheets. Six sheets are normally built up in one pack and seven packs are cured at one time in the press which gives a capacity of 42 sheets at one pressing.

Pressing

The pressroom is located directly below the assembly room in our plant and the largest press takes a full length pack, making sheets 3 ft. by 8 ft. under a total pressure in excess of 5 million pounds. The total curing time varies, but from the moment the pack is placed in the press until it is removed requires about two hours for urea material. The maximum temperature is approximately 270 deg. F. Phenolic material cures in less time. All material has to be completely cooled in the press because a certain volatile content remains even in the finished sheets. If the pressure is relieved at high temperature, the volatile in liquid form, flushes into vapor and blisters the sheet. Each batch, therefore, is cooled under pressure by water circu- (*Please turn to page 272*)

Photos across the bottom of these two pages illustrate the major operations in the manufacture of laminates. Fig. 1—Assembling impregnated sheets before going into the laminating press (Fig. 2). Fig. 3—Sanding down table top cores after edge strips have been glued (Fig. 6). Fig. 4—Careful work with small hand tools is required in finishing laminated tops. Fig. 5—Shows the big veneer presses in which the top and bottom laminates are glued to the cores

4 (PHOTOS COURTESY FORMICA INSULATION CO.)

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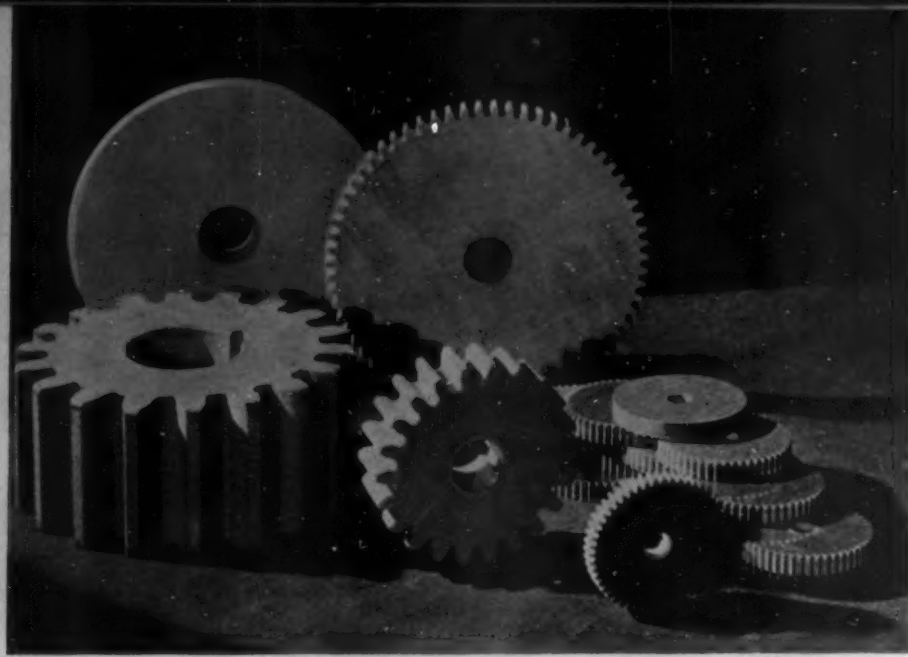


Gears at the left are laminated of Textolite by the General Electric Co. Those at the right are Insurok, made by The Richardson Company

LAMINATES FOR INDUSTRIAL USES

by P. B. LEVERETTE

ONE OF THE FIRST USES OF SYNTHETIC PHENOLIC resin was as a binder in making phenolic laminated materials for electrical insulation purposes. Before this new material had progressed very far in the insulation field, it was tried experimentally in making non-metallic gears for quiet operation and found satisfactory. From this point on, phenolic laminated materials have been used more extensively for industrial applications.

Phenolic laminated materials are divided into two classes—paper and cotton fabric base, asbestos paper and fabric being used on applications requiring high heat resistance. Each of these two classes is divided into a number of grades, developed to meet the specific requirements of industrial and electrical applications. There are three general forms, plates, rods and tubes, from which are machined the required parts for specific uses. A fourth form, simple molded shapes, with relatively uniform cross section thickness to simplify molding, is economical on large production items, where the machining operation to produce these parts from standard plates, rods or tubes is a major item of cost. Also the material can be placed in the mold to give maximum directional strength. This cannot always be accomplished on machined parts. On molded parts the finish is uniform and pleasing and does not require special refinishing operations.

Laminated materials have several predominant characteristics that collectively make it an ideal material for many uses. These advantages are as follows:

1. High ratio of strength to weight
2. Resiliency or low modulus of elasticity
3. Lightness in weight
4. Resistance to corrosion
5. Will not score or adhere to metal

Laminated phenolics provide industry with many smoothly operating, long lasting mechanical devices, among them these ball-bearing retainers made of Textolite for Norma-Hoffman ball bearings by General Electric

6. Properties are permanent at normal humidities and temperatures
7. Low heat conductivity
8. Machinability

As previously mentioned, laminated paper materials were first tried industrially as non-metallic gears for quiet operation. This type of gear was so successful in minimizing noise that other installations were made. However, these failed by stripping the teeth in a few days. It was realized that a stronger or tougher material was needed for impact load, and cotton fabric was selected to give this toughness. Gears made this way were entirely satisfactory and today are used universally where quiet and smooth operation is of importance.

To cover the complete range of gear sizes, materials have been developed, using a fine woven, cotton fabric, for electric clock gears and a coarse, cotton canvas fabric for industrial gears, as large as 5 ft. in diameter, with a possible face of 10 inches. Most gears are machined from blanks, flycut from plates or blanks molded to size. However, some, mostly bevel gears for light duty where tooth accuracy is not necessary, are molded from laminated or mascerated fabric.

The complete success of gears made from this material depends upon the following facts: High resiliency, 40 times as resilient as steel, resulting in low impact and acceleration load stresses incidental to normal gear tooth action; stability under all operating conditions, including changes in temperature and humidity; and resistance to oils, greases, gasolines and solvents.

These same properties are desirable in materials used on several types of flexible couplings, to relieve end thrust, thereby reducing wear, and to reduce vibration and minimize the load shocks and varying motor torques. All of these tend to reduce the strains on the motor or driver, thereby decreasing maintenance cost. In the gear type flexible coupling, a molded gear with internal teeth, meshed with a metal gear, offers the advantages of light weight and resistance to damage by oil or humidity conditions. Plate material can be easily machined to fit the driving lugs of the flexible insert-type coupling, giving the above advantages and also affording electrical insulation between the shafts. Molded rods may be used as the drive pins on the flexible pin type couplings and may be so designed that the pins are actually shear pins, shearing should an overload occur that might damage the driver or other equipment. Phenolic laminated materials will not score or adhere to metals. Therefore the metal parts of the couplings will not be damaged by the sheared pins.

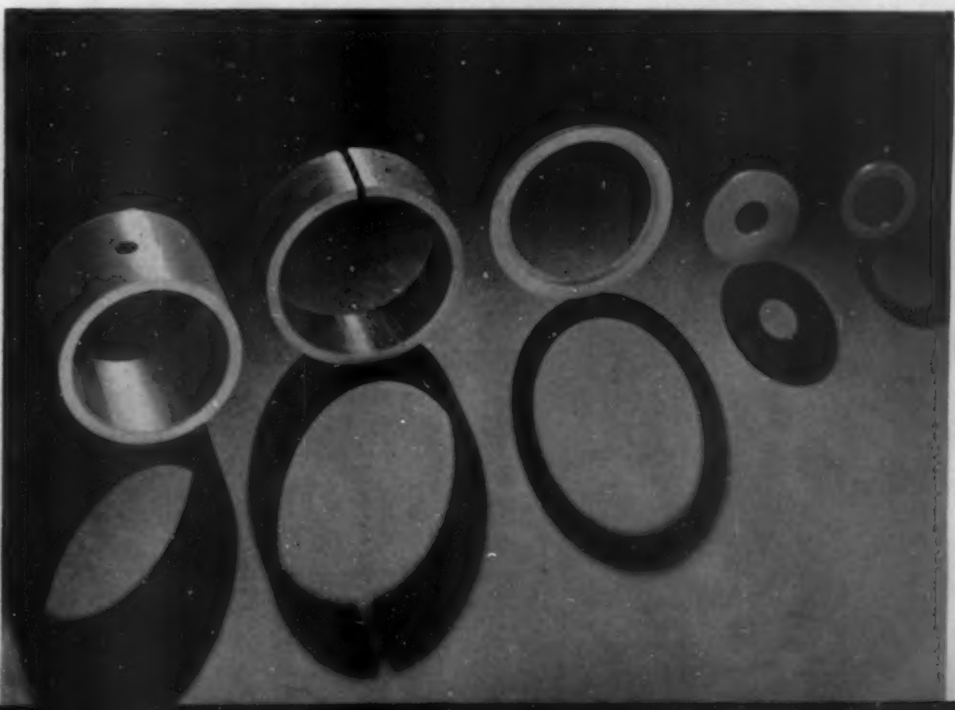
Molded friction head cones for screw machine spindles and tapping machine heads, castor wheels for hand trucks and rolls for escalators are other examples illustrating the toughness and wear resistance of laminates.

The relatively high heat resistance, 150 deg. C. and stability of paper and cotton fabric materials at elevated temperatures, plus ease of machining, has opened a new, purely mechanical application. In casting inserts into iron or steel, it is necessary that the inserts be held rigidly and accurately in position, during the core baking and casting cycles. Plate material or tubing is machined to support and locate the inserts properly, while the core is formed and baked. The laminated material is then an integral part of the core as it is placed in the mold. This procedure eliminates the possibility of inserts shifting or being displaced, insuring a perfectly molded part, reducing the expense and necessity of recasting.

Some grades of phenolic laminated materials will stand the corrosive actions of dilute acids and alkalies, certain organic solvents, moisture, steam and salt water. Therefore it is an ideal material for oil pump gears, gasoline pump vanes and thrust washers. Valve disks, pump and shut off valves, made from fabric base materials, are superior to those made from rubber or metal in many applications. They will not pit nor warp, insuring proper seating at all times and because of the resiliency and uniform structure, will not score the valve seats. Disks made from asbestos fabric can be used in hot water or steam lines, operating as high as 400 deg. Fahrenheit.

As suction box covers on paper machines, it outlasts wood several times because of its moisture and abrasion resistance. On outboard motors, thrust washers, gaskets for the exhaust seal, co-pilot lining and co-pilot bands, fabricated from plate and tubing it resists the action of salt water and insures (*Please turn to page 276*)

Parts for Johnson outboard motors (left) and roll-neck bearings with thrust collars of Textolite



The Gunnison house (above left) has exposure-proof plywood, bonded with resin film, as wall, floor, and ceiling panels. The new Mellon Institute interiors, one view of which is shown at the right, were built with walnut (Tego-bonded) Weldwood furnished by U. S. Plywood Corporation. (Photos courtesy Resinous Products & Chemical Co.)

RESINS IN WOOD FABRICATION

by R. KOCH

THE REAL ADVENT OF RESIN-BONDED PLYwood may be dated to 1934–35, although numerous introductory efforts and failures occupied the preceding years. The wood industry had become skeptical of new methods, but it also recognized that its best mechanical product—plywood—still suffered seriously from a sensitive and separable glue-line. Not until a phenolic resin film, in successful use in Europe, became available in this country, was it convinced that weather-proof plywood had become practically and economically possible.

Plywood, it may be recalled, is an improved wood product built up of thin slices (veneers) of wood glued together with grain at alternate right angles. This construction distributes the fiber strength of the wood, greatly reduces its swelling and shrinkage, and eliminates splitting. However, these mechanical advantages of plywood are wholly dependent on the strength and durability of the glue joint, which until recently has always been sensitive to moisture and mold growth. As a result plywood was definitely inadequate for any uses involving exposure.

This resin film had so many basic and incidental advantages over older adhesives that, even at a higher cost, its benefits to the plywood business could not be doubted. This film was made under careful chemical control, and was supplied in standard rolls of great uniformity. In use it is cut to size and laid between the component layers of an assembly, which is then cured for 5–15 minutes in a hot press. No moisture is introduced into the wood and with a multiple-plate press, the hourly output can be high—especially because the panels are then finished and the usual two-day drying and storage is eliminated. The resultant panel is extremely durable, completely resists cold or hot water, repels molds, is free from glue stains, and has high resistance to surface checking on exposure. With these potentialities, the wood industry rapidly proceeded to adopt the new method.[1]

By the end of 1936, the production of resin-film plywood had grown to millions of sq. ft. a month, and the installation of presses has constantly continued since. Meanwhile, a considerable body of data has been built on experience in the field and on comprehensive laboratory studies with resin film. They testify to the fact that, while it may appear a fairly simple matter, wood gluing in the improved form entails numerous factors and conditions that demand careful scientific methods.[2]

Resin-bonded plywood, of course, became so firmly established because of its appeal to consuming industries. It has now been used for years in the cabinets of such radio manufacturers as Philco, Zenith, and Wells-Gardner. Furniture makers numbering in the hundreds have introduced resin-film plywood into their better lines; some produce it themselves, like Winnebago, Union, American, Landstrom, and the Lane Co.,—who specializes in cedar chests. It has likewise found its way into numerous other types of quality cabinet work, for instance, such as in the Chrysler Airtemp and General Electric air-conditioning units.

In building construction, the application of resin-bonded plywood includes such examples as Curtis interiors, Roddis doors, and Gunnison houses, which are built of plywood throughout and have proved one of the foremost prefabricated designs in practical use. In other fields, the adoption of resin-bonded plywood is reflected by a few of the leading users: Bellanca aircraft; Herreshoff boats; Packard station wagons; Hammond organs; and Toastmaster and Overton trays.

Obviously the wood industry has learned what a demand really exists for a material of the character of wood but with unquestioned mechanical properties and dura-

bility. In fact, the first four years of resin-film bonding have reoriented the industry not only in the quality of its products but also in the scope of its markets. Today, when panelling is required for any conditions whatever, resin-bonded plywood comes into consideration at once because its good strength, beauty, light weight, and low cost are backed by assured absence of separation.

Further extension of resin bonding

The resin film, on which this development was primarily based, was designed to produce quality work in the widest sense. It develops the extreme durability of the phenolic resin class, and unquestioned water and boilproofness. Its dry film form guarantees uniformity of use on one hand and absence of stress-producing moisture on the other. These important properties, combined with many incidental features, make it unlikely that it will ever have a full equivalent, in all respects, for the class of work which it is designed to produce.

The plywood industry has also found that the film offered progressive economies in reduced waste, spoilage, equipment, floor space, and material in storage, as against older glues. Hence film-bonding, while originally utilized only for highest-quality stock, eventually displaced an increasing volume of liquid glues whose main virtues were initial strength and economy.

There still remained a large class of plywood in which ultimate quality was not a prime factor and which required very low cost, as obtainable with vegetable and soybean glues. A special case of this situation is provided in Coast and Southern softwoods, where operating methods have long been adjusted to the utilization of relatively cheap and plentiful timber. For such work, the film resin, as well as earlier types of resin solutions, seemed definitely out of the question because of expense.

Nevertheless, lower-cost plywood offered a tempting field for resins, in view of the obvious improvement they could offer in durability. Plywood makers were interested since discovering the commercial advantages of resin-bonding in the higher grade lines, and hot-press equipment for curing was now widely available. By 1937, the results of long experimental work on suitable resins reached the practical stage and this year (1938) lower-cost resin bonding has become commercial practice.

Among the experimental products contemplated during this period have been phenolic and urea-formaldehyde resins of different origin, in dissolved and powder form. Some of these products have found specialized use; most of them remained experimental. By far the most successful has been a special urea-formaldehyde type resin in aqueous solution, which is now accounting for a considerable output of durable panels in the lower price class.

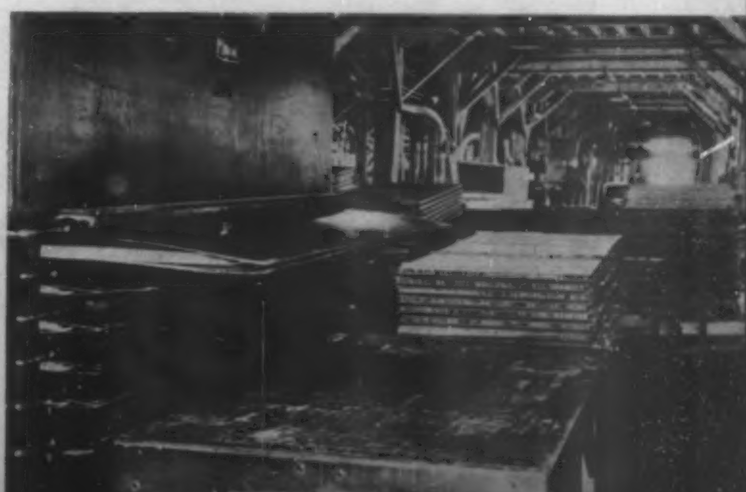
Urea-formaldehyde resin, applied as liquids, cannot in themselves be as economically used as the higher quality film, by any means known today. Better spreading equipment has been designed and remarkable reductions in quantity of adhesive applied have been achieved. Nevertheless, because of uneven and absorptive wood surfaces, variations in viscosity, and other factors, it is not yet possible to deposit a liquid resin as sparingly and still as completely as is done with dry resin sheet.

An answer was found in bulking or extending the liquid resin with certain suitable agents like flour and cassava. Since it has been found that admixture of flour to the resin up to a certain point does not noticeably impair the properties of the latter, the mechanism is probably one of better distribution of the available resin and of its reduced absorption before curing by the wood. In any event, when used with a fairly high ratio of flour, and applied with modern accurate spreaders, the urea-formaldehyde type resins can produce a bond at low cost that has great strength and prolonged resistance to cold water. Because they also cure rapidly in the hot press at moderate temperature they yield an output that cannot be met with the older liquid adhesives.

Beyond a certain point, the addition of flour to urea-formaldehyde solutions increasingly impairs their distinctive properties as adhesives, notably their water-resistance and durability. However, even at high flour ratios (4 to 1 of resin) the durability obtained is still greater than with older type glues, and the material cost is reduced to very low figures. With the advantage of speedy output by the hot process still remaining, it will be seen that synthetic resins are now in a position to displace animal and vegetable glues throughout the entire plywood line.

Urea-formaldehyde liquid resins, once thoroughly tested, received a commercial reception similar to that accorded to the phenolic film. Within their limitations, they are already producing an excellent quality of panel in numerous industries, e.g., radio and furniture work on one hand and softwood (*Please turn to page 270*)

Federal Distributing Co. builds its new service stations (left) of Resnprest, a waterproof, all-weather plywood bonded with Durez resin and widely used in boat building. (Photo courtesy General Plastics, Inc.) Catabond, a new phenolic glue made by the Catalin Corp., is being used on the plywood panels seen coming from the hot press below



This photograph of a new car becomes alive and almost three-dimensional when illuminated from the back. It is a photo enlargement laminated in a urea panel. (Photo courtesy Beetle)

TRANSLUCENT UREA LAMINATES

by W. H. MacHALE

MANY WORDS AND MUCH SPACE HAVE BEEN devoted to the versatility of urea resins, their use in molding powders, cements, lacquers, textiles, and opaque laminating syrups, but little has been said about the translucent laminated products which are available through its use. Since this year has seen a great increase in variety of application of this laminated material, it is felt that it will soon obtain its rightful recognition in the family of plastic products.

Translucent urea laminated panels, in the completed form, are composed of a series of sheets of paper which have been impregnated with resin, assembled one on top of the other for required thickness, and compressed into a homogeneous sheet under the combined action of heat and pressure.

A high grade absorbent paper, either rag or alpha, is impregnated with a urea-thiourea syrup, and dried to the proper volatile at a temperature of 190 deg.–230 deg. F. The coated paper contains about 45–65 percent resin, but frequently surface sheets are given a double coating to raise the resin content to 60–65 percent and thereby increase the panel's weather resistance. The treated sheets are then assembled and pressed at 1500 lbs. per square inch at a temperature of 130 deg. to 132 deg. C. for a period of 20 to 30 minutes.

The completed sheets may range in thickness from .030 in. to .500 in. In the thinner sections the material has a certain degree of pliability and may be bent over fairly short radii. Thin sheets are likely to be more difficult to produce because of the necessity of absolutely even pressures in fabrication to insure the absence of opaque spots.

Natural or unpigmented panels are a translucent pearl white color. On exposure to sunlight this color will turn slightly yellow, but will reach stability in about one to two months' time. This reaction is due to the effect of sunlight on the paper and on the thiourea resin.

The markets or applications for translucent urea laminated may be grouped into two general classifications. They are lighting, and display or decoration. The translucent panels, particularly in sections of $^1/_8$ in. to $^1/_{16}$ in. thickness give excellent diffusion and transmit about 46 percent and 53 percent light, respectively. The amount of light transmitted increases rapidly as the panel thickness decreases.

In the home, this material in sheet form serves as an excellent diffusing face for recessed ceiling lights, corner light troughs, and fan lights over the door. In office buildings, department stores and theaters, its potential application is considerably wider. Here the use of trough or cove lighting is likely to be greater and the need for light weight, shatterproof diffusing media of greater importance because of the greater safety required, and the demand for reduced cleaning and handling costs.

(Please turn to next page)

Theater marquees which are ordinarily brightly illuminated and frequently altered for decorative purposes, benefit through the use of this light weight plastic, not only as a result of less frequent breakage, but through a reduction in danger to pedestrians and workmen. The material being somewhat pliable may be bent to conform to new lighting ideas and designs without the necessity of mold construction. However, any bent sections must be held in position, otherwise the sheet will straighten out.

In the office, partitions and Venetian blinds which do not exclude light may be erected cheaply between desks or rooms to insure privacy. Perhaps some of the points mentioned above can be more clearly understood if this material's use at the New York World's Fair is discussed. In front of the transportation building there are two pylons each of which is over 140 ft. high. Up the face of each there is a column or section of translucent panels—the largest measuring 4 feet by 4 feet. Each panel is $^1/_8$ in. thick, and at night when these towers are illuminated the effect is one of two columns of light rising into the sky. The reasons for this use are quite apparent; the light weight of these panels permitted the use of lighter structural materials. The sway of these pylons in the wind will have little effect on the tough pliable sheets, thus diminishing cracking. If breakage does occur, the hazard from broken pieces is eliminated because of the plastic's shatterproof qualities.

In the vestibule of the perisphere the material is again used primarily because it may be bent to form a curved translucent ceiling. Visitors entering the sphere must have ample light, but their attention should not be diverted by the exhibits until they are safely on the moving runway. Many applications are springing up at the Fair which will be in evidence when this article is in print. The second great use for translucent urea laminated is somewhat less well known, but should present as great a market as that of lighting; this market consists of the material's use for advertising signs, photo murals and decorative lighting.

Colors and designs are almost unlimited and may be obtained through the use of dyed syrups, spraying printed paper or by means of silk screen printing. If the reader recalls the method of manufacture of this laminated material, he will readily understand that one of the sheets composing the assembly may carry a design, a water color drawing, a photograph or an advertising message. When the assembly is pressed, the sheet bearing the design may be placed just under the outer sheet becoming thereby visible yet protected by a transparent cover of resin and paper. This process has been used with great success in the construction of exit signs, road guides, night club decorations, advertising signs and photo murals. The brilliant colors available, their permanence and the effects obtained by the diffusion of light through the panels make these applications of considerable promise. Many of the uses mentioned herein will be seen at the New York World's Fair. Translucent laminated has found a great and varied use there both as a decorative medium and a lighting medium. Its wholesale introduction by the Fair should start it well along in its career as a matured member of the urea family.

This lion's head in brilliant colors has the translucency of glass without being fragile. It was laminated for Reid, Murdoch Co.

Socony-Vacuum Oil Co. lights this urea laminated sign with neon. Both this and the lion's head are Insurok laminated by Richardson Co.

RESINS IN WOOD FABRICATION

(*Continued from page 265*) panels on the other. They seem particularly adapted to fir and similar species, where they overcome the roughness and inequalities of the veneer and afford a durability that was previously almost unknown. To the Coast fir industry this is of special importance because it adds the concept of quality to that of quantity. Resin-bonded fir plywood has consequently been able to enter many fields where weather and water exposure are to be expected.

As already mentioned, various other types of resin have been developed for use in the hot bonding or laminating of wood. Although they have not yet enjoyed wide commercial reception, they are themselves of interest and may lead to desirable future developments. Phenolic resins in alcoholic solution are well known and generally give high-quality results. They must naturally be applied as liquids. Phenolic and urea-formaldehyde resins in powder form have also been reported in the past year. Unlike earlier tests with resin powders, these are not dusted on the wood but are dissolved by the user. In effect they thus become liquid resins and their ability to meet practical conditions of uniformity and stability are primary questions yet to be answered.

It may be mentioned at this point that the conditions for a *commercially* successful resin adhesive are not always immediately obvious. For economy, the material cost must be reasonable, the curing time short, wastage low, and the application itself uniform and economical. On the other hand the material must also have stability against pre-cure and in its economical application there must be absolute assurance against insufficient adhesion. For quality and operating ease, it must give uniform results under fixed conditions, it must be versatile enough for use in different constructions, it may not harm the stock (by staining, etc.), and it must give maximum durability of joint in relation to cost. Other factors like storage, stability, odor, effect on tools, and many more, have been decisive in the acceptance of resin adhesive. Thus when this article indicates only a few resins as having been found practicable, it is in the knowledge that to date practically the entire commercial demand has been supplied by not more than four products, one of which has far outweighed the other three.

Other developments

The thought of bonding wood with a cold-setting resin has naturally appealed to many who see an economy in the elimination of hot-press equipment. Actually, in a wood working plant with reasonable output the cost of a hot press becomes insignificant within a short period of use: one plant has already installed 6 in 3 years. Furthermore it is in the nature of hot pressing to produce high-quality finished panels almost instantly, without costly tie-up, drying, and storage. The hot-press in itself is therefore a factor of economy, so long as there is no durable adhesive in sight that will bond cold in a few minutes and still be stable in storage.

Designed by Barnes & Reinecke, this Toastmaster Hospitality Tray is resin bonded with Tego film

Yet a cold-setting resin would seem to have a legitimate field, namely where a hot-pressed joint is impractical for mechanical reasons. Such applications would be furniture joints, compound lumber, special form work, and several more, where the resin would provide water and exposure-proofness not yet available. There is now reasonable expectation of the development of such a product and if this hope is borne out by the test of time, there will remain no type of wood joining in which resin bonding and its durability are not readily applicable.

A special development is represented by so-called "Improved Wood," which further extends the basic idea of plywood. Instead of 3, 5, or 7 layers of wood, with intervening layers of resin or glue, an assembly is built up of numerous thinner veneers of wood, and a corresponding number of layers of resin film between. Obviously the ratio of resin to wood rises as the number of layers increases, and a product of entirely new properties is created. Just where the assembly ceases to be plywood and becomes "Improved Wood" is an academic question, but it is readily possible to select a material anywhere along the scale to obtain its specific properties. At one end it will have the resilience and tensile strength of wood; at the other, it will have more of the hard character of the cured phenolic resin.

Such assemblies also permit variation and adjustment in their mechanical construction, according to the species, thickness and grain direction of the layers of wood, and to the pressure during cure. It will be recalled that wood as a whole is distinguished by resiliency and by high tensile strength along the grain. If the wood layers are all cross-plied, the panel has high strength in both directions, although not the maximum obtained in only one direction by lamination, i.e., parallel grain throughout. High pressure during the cure will also produce a denser, harder panel than that obtained in normal plywood work. In all cases the cured resin not only binds the layers inseparably together, but transmits its own properties markedly to the panel as a unit. Thus multi-ply panels of high density may appear as homogeneous materials in which the identities of wood and resin are practically eliminated.

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From this general review of synthetic resin developments in the wood industry it will be apparent that the newer chemical product has had a basic effect on an old material and industry. But in this case the synthetic resin has not replaced the wood; it has improved it and made its desirable properties much more readily and permanently available.

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[1] "Resin Film as a Plywood Adhesive," by T. D. Perry. *Modern Plastics*, December, 1936.

[2] "Hot Pressing Technique for Plywood," by T. D. Perry and M. F. Bretl. Trans. A. S. M. E., Jan., 1938.

HOW LAMINATES ARE MADE

(*Continued from page 261*) lated throughout the press platens which are channeled for this purpose as well as for steam which is used to heat them. A cooling tower is provided outside the building to constantly reduce the water temperature while the presses are operating.

Buffing

No matter how efficiently the laminated sheets are handled, minute scratches always appear which must be buffed out. This is done on a machine which accommodates a full size sheet and requires about two minutes to refinish the entire surface, using cloth buffs running at 3600 R.P.M. These buffs are about 24 in. in diameter. The operator holds the sheet, running half of it into the buff, then turning it around, the other half is buffed in the same way. Sometimes there are local areas in a sheet which require local hand buffing and the ease with which this is accomplished indicates a good simple method for repairing damages in the surface of table tops or other applications, should they occur.

Using the product

Generally speaking, it was our idea when we entered the decorative field to establish ourselves as sheet makers and to allow others to do the engineering and fabricating on the job. In order to do that, it became necessary for us to go into the fabricating field to learn all the angles and transmit our findings to others who used the sheet stock. The result was that an extensive furniture plant has been developed where we fabricate about 40 percent of the finished sheet, the remainder is done by customers.

Table tops, which represent one of the more prominent items for which decorative laminated material is used, are all made to order. In their fabrication, a wood core is made first. Laminated material is then cut to size; the table edge is put on first with glue, then the top and bottom are glued in place. By this method, the top and bottom extend over the edge protecting it from being damaged in subsequent operations and in use. The wood core, top and bottom, is spread with casein glue, then the laminated sheets are put in place and the entire top is placed into a hand press. The glue dries in about four hours under a pressure of 75 to 100 lbs. per square inch. Sometimes the top can be removed from the press before it is dry thus relieving the press for other duty but it cannot be worked on until the four hours have elapsed to allow it to thoroughly dry. Hand presses are used exclusively for this work because they lend themselves to quick changes in size. The process is really a hand job all the way through and is done in much the same manner as wood veneering, using the same kind of labor and equipment—planes, files, sandpaper and such.

The use of laminated materials for decorative doors is increasing rapidly and they are made up in about the same way as tables. These doors may be used inside or outside because the casein glue never lets go. There is almost no limitation to the variety of decorative inlays and color, and architects with a flair for modern decoration find many uses for them.

Industrial

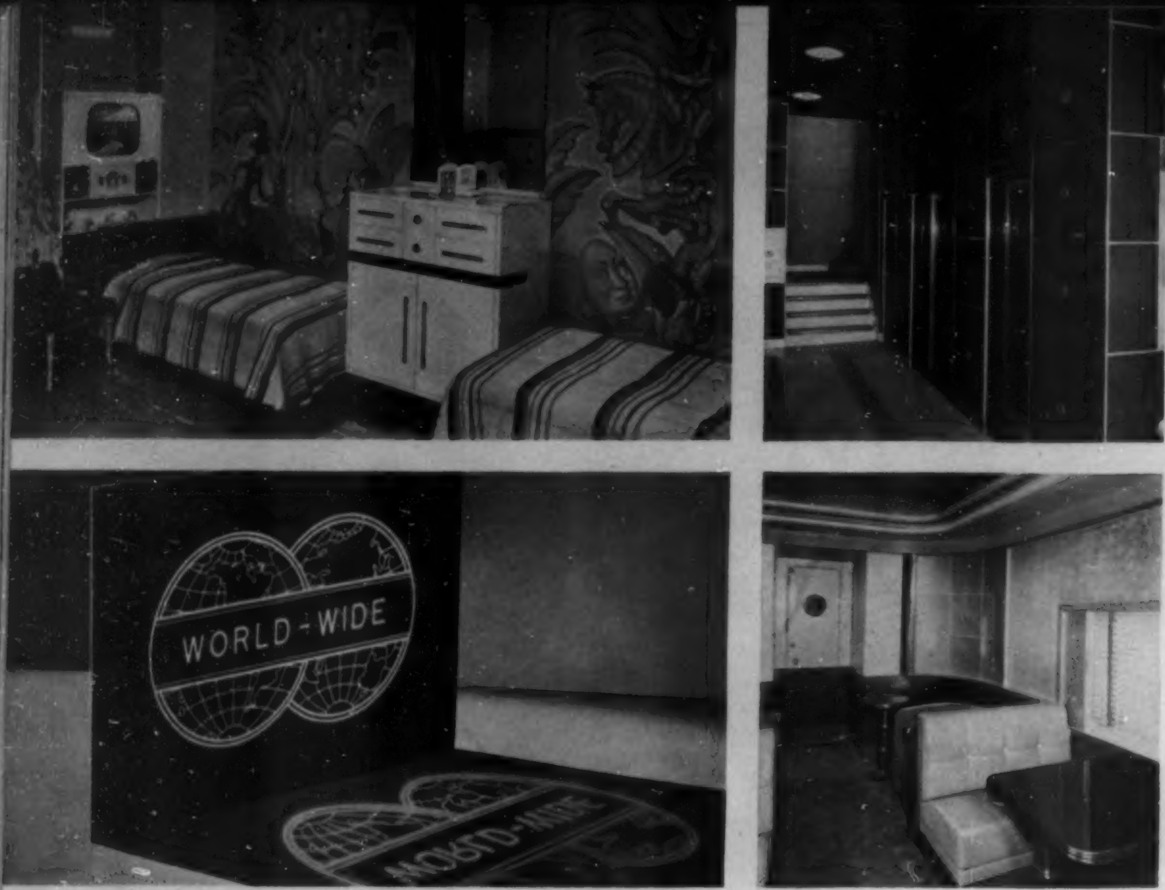
We also make a great deal of industrial laminated material such as gear blanks, breaker strips, sheets, rods and tubes for insulation but since these industrial products are the subject of another article appearing in this same issue I shall conclude with pertinent thoughts on the appropriate application of the decorative material in architectural use.

Architecture

One thought that I would like to convey is that the final result of the impregnating and curing operations is a homogeneous material from top to bottom. The resinous material is continuous from top to bottom as is the fiber content. There is no layer in the sheet where you step from one kind of material to another having different characteristics whereby concentrated and possibly destructive stresses can develop as a result of movements of the material due to changes in temperature or other atmospheric conditions.

To illustrate, consider by comparison painted steel. The steel and paint expand and contract differently under temperature. Unless the paint retains its flexibility the two materials eventually part company due to continual reversal of strain. This condition cannot exist in a laminated sheet as the resin content of each lamination under pressure flows into and bonds with adjacent laminations so that no cleavage line results. (*Please turn to next page*)

Table tops in the main lounge of the *SS Nieuw Amsterdam* of the Holland American Line are of Formica



Upper left: Beds, bureau, bookends, gold fish bowl and radio of Lamicoid. Upper right: Elevator facings at 261 Broadway, N.Y.C., and table tops (lower right) on the *Broadway Limited* are of Formica. Lower left, shows a laminated display of Lamicoid

Lasting finish

For architectural purposes it is necessary to choose materials that endure. If the material is not chemically inert, over a period of time it will dissolve or disintegrate or rot but these laminated materials are chemically inert. All of the physical characteristics are permanent—the material will not rot like wood nor rust like iron, fade like some structural stone; its surface will not become increasingly brittle like paint, varnish or shellac. It is color fast and it presents a maximum of surface resistance to abrasive wear in comparison with other materials. All of these physical characteristics are inherent in the sheet when it leaves the press after curing and the curing action is not reversible. Heat has no effect on it at temperatures at or below the curing temperature. If all these characteristics are inherent its finish in the absence of wear will require no maintenance.

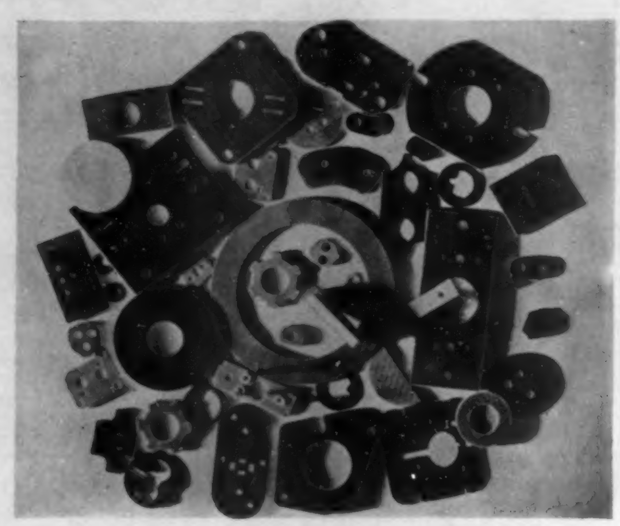
Laminated sheets can be made in any color from white to black for which a pigment can be found that is chemically inert and light fast. If a certain color is demanded and a satisfactory pigment cannot be found, we just don't make that color. Practically any wood that can be cut into thin veneers approximately .015 in. thick can be made into sheet by our process. In so doing the wood has become completely waterproofed, it cannot warp, stain, check or rot. Its color and grain characteristics have been retained and made permanent and it has been protected from wear by a hard resinous film that has all the characteristics of our other laminated materials.

Construction

It is not practical to construct bookcases, telephone booths, bars, table tops, and cabinets from $^1/_{16}$ in. sheet. While we can and have built heavy sheets, the cost for decorative and utility purposes becomes too high and even if heavy sheets were available, the fabrication cost would be excessive. It is customary, therefore, to veneer sheet material to plywood core and use this product as lumber from which telephone booths, bars, table tops, cases and counters have been fabricated in much the same way as they would be built from wood. This product can be handled with woodworking tools and since all exposed surfaces are resinous, the finished product is essentially a laminated piece. The wood core is almost completely encased in impervious sheet, hence it is protected from all the factors that eventually lead to its destruction if exposed.

New specifications and regulations will soon be in force for fireproof partitions and corridor walls on shipboard. For this purpose asbestos boards have been produced to which we are able to adhere our surfaces for decorative purposes. A corrugated asbestos paper board suitable for core material is also standard with laminated surfaces. Both of these materials have been tested by Government agencies and both with and without our material have tentative approval. In addition, it is possible to adhere laminated surfaces to bonded metal for elevator cab walls and in wall areas in metropolitan districts where strict fire regulations are in force.

At the left is a device for examining stockings which is produced by Synthane Corp. by a molding-laminating process. The impregnated sheets are laminated together with heat in a shaped mold. Below is a group of electrical parts fabricated from Insurok



LAMINATES FOR INDUSTRY

(*Continued from page 263*) water tight seals. Plating barrels, fabricated from fabric plate, give excellent service when used in cold plating solutions, as does tubing with molded fittings for pipes handling chemicals.

The acid resisting and high ratio of strength to weight properties were recognized in the rayon industry and laminated was adopted as the material for molding spinning buckets. These buckets are approximately 8 in. in diameter and spin on a vertical shaft at 8000 RPM, as the wet rayon yarn is fed into the top and caked around the inner wall. A load of yarn weighs approximately 3 lbs. so that the bucket must have sufficient strength to withstand the stress caused by the centrifugal force created by the mass of rayon and the bucket itself.

Test tube racks are easily fabricated from plate laminated and will not absorb spilled liquids, are easily cleaned, have a pleasing appearance and will stand rough handling. This is only one of the examples of the small, indispensable articles used every day by scientists and chemists that can be improved by the use of phenolic material. This same material has proven successful for making the electrolytic heads, replacing metals, of an electrolyzing unit because of its corrosion resistance. The complete assembly, including the handle, two screws and head are fabricated from rods and tubing.

Several years ago, many rare specimens of fish, in a New York Aquarium were dying and an investigation showed that the metal pump contaminated the water supplied to the tank. After making tests on several materials, a new pump was designed and built, using 5 grades of phenolic laminated, so that no water came in contact with the metal parts of the pumps. To date these pumps are still giving satisfactory service and have entirely eliminated a serious condition.

To increase the life of ball bearings at high speed, a non-abrasive, light, strong and easily machined material was needed for the ball retainer rings. Laminated fabric tubing was tried. Because of the low coefficient of friction and light weight, they require very little lubrication, yet the efficiency and life of the bearings so constructed has been materially increased.

To protect soft copper wire from abrasion as it passes through the drawing and cabling machine, laminated guides and rolls are used. Asbestos fabric base material is also used as tracks and sprockets for supporting and driving the conveyor chains in ovens at high temperatures, for treating cloth for electrical insulation purposes. The material being non-abrasive, does not wear the conveyor and eliminates the possibility of deposited metal particles on the treated cloth. Doctor blades for paper machine rolls will not cut or score the rolls during operation. For removing light rust and refinishing the rolls after brief shut-downs, a special material containing an abrasive substance has been successfully used.

Pickers, used on looms for weaving cloth, must be tough, have a low coefficient of friction and not be affected by changes in humidity and temperature. Molded laminated pickers will fill all these requirements with added advantages that cannot be obtained with other materials. By molding to shape it is not necessary to use rivets or metal fastenings in the head, which might damage the shuttle tip or chip the openings in the box. Inserts of a soft material molded into the stick hole, give added protection to the picker stick. An added advantage is longer life, since molded pickers outlast the conventional picker several times, if properly adjusted.

Bearings made from laminated fabric base materials for heavy duty applications were tried several years ago and proved successful almost from the start. Since then, many installations have been made in rolling mills for rolling sheet and nonferrous metals. They are used on plate mills, bar and billet mills, rod mills, strip mills, skelp mills, tube mills, pipe welding rolls, three high sheet

mills, cold sheet mills, structural mills, as well as on auxiliary apparatus. About the only mills where laminated phenolic bearings are not practical are the two high hot sheet mills, where the rolls are operated at temperatures of 500 to 800 deg. F. and the necks cannot be water cooled.

Since the heat conductivity of phenolic laminated material is very low, approximately 2 BTU per sq ft. per in. of thickness, per hour, per deg. F., it is necessary to provide some external means for reducing the heat of friction at the bearings. This is done by spraying water on the roll necks and at the same time the water acts as a lubricant. If properly and adequately supplied with water, laminated bearings are stable, long wearing and efficient. If the water supply should fail, the bearings will overheat and char on the surface, materially reducing the bearing life.

The economies effected by the use of laminated bearings are responsible for their increased use in the rolling mill industry. Of major importance is the saving in power, brought about by the low coefficient of friction, with water lubrication. Savings in power range from 15 to 40 percent and in some cases have been reported as high as 60 percent. When properly installed and lubricated, these bearings will outlast bronze or babbitt bearings from 5 to 10 times.

Why are phenolic laminated bearings successful? From a series of laboratory tests it has been found that at high bearing pressures the coefficient of friction is extremely low, indicating that there is film lubrication. As previously stated, the modulus of elasticity of phenolic laminated bearings is very low, considerably lower than for bearing metals. Considering the usual theory for oil film lubrication on rigid bodies, the pressure tends to concentrate at the point of minimum thickness of the film and such pressure is sufficiently high to cause an appreciable compression of the laminated bearing, distorting it in such a way that the oil film does not decrease in thickness as much as it would with the rigid bearing under the same total loading. This results in a more even distribution of pressure over the entire lubricating film and less pressure concentration.

Another advantage of phenolic laminated bearings is the lack of scoring of the journals, should the lubrication system fail. Even though the surface of the bearing became badly charred, it would not score the polished journal surface, nor will laminated bearings cold flow or squeeze out as do babbitt and bronze under heavy and intermittent impact loads.

Other applications for phenolic bearings are in the manufacture of paper, where the wet process makes water lubricated bearings possible and in some cases desirable, or on any application where the heat of friction can be reduced by the use of water or other means. On grease lubricated bearings that are used intermittently, the heat of friction is carried off through the shaft; also on bearings subjected to heavy impact loads in intermittent service and on similar applications where grease or oil must be used sparingly to keep from contaminating the finished product.

A new use for synthetic phenolic resin is as a binder for plywood. The resulting bond between plies is strong, uniform and waterproof, thereby increasing the potential uses of the material. It is possible by varying the type of resin, cure pressures, cure temperatures and time, thickness and type of veneer used and cross banding, to produce a material of unusual strength. In fact these conditions can be varied so that the resulting material will have a shear strength very nearly approaching the tensile strength. This provides a means for improving the directional properties, which is desirable in many applications.

A very decided advantage of this material is the light weight resulting in high ratio of strength to weight. This one advantage, as the materials are further developed, will probably increase the use of wood in airplane construction where the ratio of strength to weight is of prime importance. It is entirely possible that phenolic bonded plywood will replace many parts now made from metal, including structural members.

It is quite evident that phenolic laminated materials have a definite place in the industrial picture. Yet for each known use today there are numerous other applications that have not as yet been exploited.

Dials, lampshades, Venetian blinds, advertising and theater signs and many other decorative and industrial units are fabricated from translucent laminated materials. Those illustrated at the left are of Lamicoid. (Photo courtesy Mica Insulator Co.)

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BIBLIOGRAPHY AND NOMENCLATURE

SELECTED BIBLIOGRAPHY OF BOOKS AND MAGAZINES ON PLASTICS

by CARLETON ELLIS

"A. B. C. of Plasticizers." 1937. New York: Chemical Publishing Company.

Abraham, H., "Asphalt and Allied Substances." 4th Edition, 1938. New York: D. Van Nostrand Co.

"A.S.T.M. Standards." 1936. Part II. Non-Metallic Materials. "Tentative Standards." 1937. "Standards on Electrical Insulating Materials." 1937. "Standards on Rubber Products." 1937. Philadelphia: American Society for Testing Materials.

Bakelite Review. New York: Bakelite Corp.

Barron, H., "Modern Rubber Chemistry." 1938. New York: Chemical Publishing Co. of N. Y., Inc.

Barry, T. H., Drummond, A. A., and Morrell, R. S., "The Chemistry of Natural and Synthetic Resins." 1926. New York: D. Van Nostrand Co.

Barry, T. H., "Natural Varnish Resins." 1932. London: E. Benn, Ltd.

Bell, L. M. T., "The Making and Moulding of Plastics." 1936. London: Hutchinson's Scientific and Technical Publications.

"Bibliography of Plastics." 1933. London: Science Museum Library.

Bingham, E. C., "Plasticity and Fluidity." 1922. New York: McGraw-Hill Book Co., Inc.

Bonwitt, G., "Das Celluloid und seine Ersatzstoffe." 1933. Berlin: Union Deutsche Verlagsgesellschaft Zweigniederlassung.

Brandenburger, K., "Herstellung und Verarbeitung von Kunstharzpressmassen" (4 volumes). Volume I. "Die Presstecknik." 1935. Volume II. "Pressen und Pressverfahren." 1935. Volume III. "Presswerkzeuge und Verarbeitung von Kunstharzmassen." 1936. Volume IV. "Pressmischungen, geschichtete Produkte und deren Aufbereitung." 1937. Munich: J. F. Lehmanns Verlag.

British Plastics and Moulded Products Trader. Monthly magazine. London: Plastics Press Ltd.

"British Plastics Year Book." 1938. 8th Edition. London: Plastics Press Ltd.

Burk, R. E., Thompson, H. E., Weith, A. J., and Williams, I., "Polymerization and Its Applications in the Fields of Rubber, Synthetic Resins and Petroleum." 1937. New York: Reinhold Publishing Corp.

"Chemical Engineering Catalog." 22nd Annual Edition. 1937. New York: Reinhold Publishing Corp.

Daniels, R. G., "The Manufacture of Nitrocellulose Lacquers." 1933. London: Leonard Hill, Ltd.

Delorme, J., "Toute l'Industrie des Matières Plastiques." 3 Volumes. 1936. Paris: Les Editions Technique et Textile.

Ellis, Carleton, "The Chemistry of Synthetic Resins." 2 Volumes. 1935. New York: Reinhold Publishing Corp.

Ellis, Carleton, "The Chemistry of Petroleum Derivatives." Volume 2. 1937. New York: Reinhold Publishing Corp.

Faraday Society Symposium, "The Phenomena of Polymerization and Condensation." 1935. London: Gurney and Jackson.

Faust, O., "Celluloseverbindungen und ihre besonders wichtigen Verwendungsgebiete dargestellt an Hand der Patent-weltliteratur." 1935. Berlin: J. Springer.

Fischer, E. J., "Laboratoriumsbuch für die organischen plastischen Kunstmassen." 1938. Halle: Verlag Wilhelm Knapp.

Gardner, H. A., "Physical and Chemical Examination of Paints, Varnishes, Lacquers, and Colors." 1937. Washington: Institute of Paint and Varnish Research.

Hemming, E., "Plastics and Molded Electrical Insulation." 1923. New York: Reinhold Publishing Corp.

Houwink, R., "Elasticity, Plasticity and Structure of Matter." 1937. New York: The Macmillan Co.

Houwink, R., "Physikalische Eigenschaften und Feinbau von Natur- und Kunstharzen." 1934. Leipzig: Akademische Verlag.

Jones, A., "Cellulose Lacquers, Finishes, and Cements." 1937. London: Griffin and Co., Ltd.

Karo, W., "Kunstharze." 1932. Berlin: Allgemeiner Industrie-Verlag.

Kausch, O., "Handbuch der kunstlichen plastischen Massen." 1931. Munich: J. F. Lehmanns Verlag.

Kline, G. M., "Organic Plastics." 1936. National Bureau of Standards Circular C411. Washington: Government Printing Office.

Kränzlein, G., and Lepsius, R., "Kunststoff-Wegweiser." 1937. Berlin: Verlag Chemie.

Kruger, D., "Zellulose Azetate und die anderen organischen Ester der Zellulose. 1933. Dresden: Th. Steinkopff.

Krumbhaar, W., "The Chemistry of Synthetic Surface Coatings." 1937. New York: Reinhold Publishing Corp.

Kunststoffe. Monthly magazine. Munich: J. F. Lehmanns Verlag.

Lipscomb, A. G., "Cellulose Acetate: Its Manufacture and Applications." 1932. London: E. Benn, Ltd.

Lockrey, A. J., "Plastics in the School and Home Workshop." 1937. New York: Governor Publishing Corp.

Main, W., and Chaplet, A., "Toutes les matières plas-

tiques artificielles." 1936. Paris: Desforges Librarie des Sciences Pratiques.

Materie Plastiche. Monthly magazine. Milan: Materie Plastiche.

Mehdorn, W., "Kunstharzpressstoffe. Eigenschaften, Verarbeitung und Anwendung." 1934. Berlin: V.D.I.-Verlag.

Mienes, K., "Celluloseester und Celluloseather unter besonderen Berücksichtigungen der Benzylcellulose." 1934. Berlin: Chem.-Techn. Verlag Bodenbender.

Modern Plastics. Monthly magazine. New York: Breskin and Charlton Publishing Corp.

Morrell, R. S., Barry, T. H., Britton, R. P. L., and Langton, H. M., "Synthetic Resins and Allied Plastics." 1937. New York: Oxford University Press.

Müanyag-ipar. Journal of the Hungarian Artificial Resin Products Association. Budapest, Hungary.

Naunton, W. J. S., "Synthetic Rubber." 1937. London: The Macmillan Co.

Nouvel, O., "Die Industrie der Phenol-Aldehyd-Harze." 1931. Halle: W. Knapp.

Plastics. Monthly magazine. London: Temple Press Ltd.

Plastics Industry in America. Supplement to Thomas' Register of American Manufacturers. 1937. New York: Thomas Publishing Co.

Plastische Massen. Monthly magazine. Berlin: Verlag Physik.

Pansegrau, W., "Deutsches Jahrbuch für die Industrie der plastischen Massen 1937/1938. Berlin-Wilmersdorf: Verlag Wilhelm Pansegrau.

Rahm, L. F., "Plastic Molding." 1933. New York: McGraw-Hill Book Co.

Raschig, F., "Resinol-Schnellpressmassen. Die Presstecknik der Phenolplaste." 1936. Ludwigshafen: F. Raschig.

Revue Générale des Matières Plastiques. Monthly magazine. Paris: Les Editions Technique et Textile.

Rowell, H. W., "The Technology of Plastics." 1936. London: Plastics Press Ltd.

Scheiber, J., and Sändig, K., "Die künstlichen Harze." 1929. Stuttgart: Wissenschaftliche Verlags. English translation by E. Fyleman, "Artificial Resins." 1931. New York: Industrial Book Co., Inc.

Scheiber, J., "Kunststoffe." 1934. Leipzig: Akademische Verlags.

Sommerfeld, A., "Plastische Massen." 1934. Berlin: Julius Springer.

Staudinger, H., Die hochmolekularen organischen Verbindungen-Kautschuk und Cellulose." 1932. Berlin: Julius Springer.

Sutermeister, E., "Casein and Its Industrial Applications." 1927. New York: Reinhold Publishing Corp.

Technical Service Library List (for paint, lacquer, plastics, and allied industries). 1937. London: Rex Campbell and Co., Ltd.

Transactions of the Institute of the Plastics Industry. Semi-annual publication. London: Plastics Press, Ltd.

Tschirch, A., and Stock, E., "Die Harze." Volume II, 1936. Berlin: Gebrüder Borntraeger.

Ulmann, M., "Azetylzellulose-Folien und -Filme." 1932. Halle: W. Knapp.

Vieweg, R., "Elektrotechnische Isolierstoffe." 1937. Berlin: Julius Springer.

Warren, H., "Electrical Insulating Materials." 1931. London: Benn.

Wilcox, J. K., "Bakelite: A Bibliography." 1931. Chicago: John Crerar Library.

Worden, E. C., "Nitrocellulose Industry." 1911. New York: D. Van Nostrand Co.

Worden, E. C., "Technology of Cellulose Esters." 1916. New York: D. Van Nostrand Co.

Worden, E. C., "Technology of Cellulose Ethers." 1933. Millburn: Worden Laboratory and Library.

"Zur Entwicklung der Chemie der Hochpolymeren Kunststoffe, Kautschuk, Anstrichmittel, Cellulosederivate." 1937. Berlin: Verlag Chemie.

NOMENCLATURE

by CARLETON ELLIS

IN THE RAMIFICATIONS OF THE PLASTICS INdustry many fields are touched upon. The binder is a resin or resinous composition which brings in chemistry, particularly colloid chemistry. Compounding the binder with fillers (if used) and auxiliaries is the next step. Planning appropriate molding equipment and properly molding the material to form a finished article is still another arena of specialized technique; and finally testing to see whether the product is fit for a particular use. Each step includes a separate art and nomenclature. To cover the entire series must perforce be made up of terms taken from the individual fields. The following is a selected list of terms in glossary form designed to touch upon the whole.

Alkyd resin—Any condensation product involving a polybasic acid and a polyhydric alcohol. Typical examples are phthalic glyceride and its modifications containing combined fatty acids or rosin.

Aminoplast—General terms for synthetic resins from amino or amido compounds. A typical example is urea-formaldehyde.

Amorphous—Devoid of crystalline structure. This condition is rare. Many substances which are apparently amorphous show microcrystallinity, particularly under x-ray examination.

Artificial rubber—Products possessing the physical properties of caoutchouc. Neoprene, Thiokol and the German butadiene product, Buna, are examples.

Asphalt—A dark-colored, viscous to solid hydrocarbon complex including: (a) The easily fusible bitumens often associated with a mineral matrix, not having a waxy luster or unctuous feel; (b) fusible residuums obtained from the distillation, oxidation, etc., of bitumens.

A-Stage resins—Thermosetting resins reacted only to the initial stage where they are soluble and fusible. The normal stage of a resin used for impregnation.

Balsams—Natural vegetable exudations consisting of resins mixed with volatile oil. The name is also applied to products having the physical characteristics of the natural balsams but produced by reactions which normally lead to resinous materials. For example, Rezyl Balsams.

Bitumen—A naturally occurring or pyrogenous hydrocarbon complex insoluble in water but soluble in carbon disulphide. Color and hardness variable.

Bonding strength—The amount of adhesion between a binder and filler. More specifically, the measure of the extent to which the composite layers of a laminated product are bonded together.

Brittleness—Liability to break, generally to a conchoidal fracture.

B-Stage resins—Thermosetting resins reacted to a stage where they soften when heated and swell in contact with liquids but do not entirely fuse or dissolve. This is the preferred stage for the resin in molding compositions.

Bulk factor—The ratio by volume of the loose molding powder to the resultant finished article.

Casting—Forming a material into a shape by pouring it when liquid into a mold. The product from the mold is used as such or mechanically worked in various ways to the final articles, as by sawing, cutting, blanking, turning, drilling, forming, swaging, grinding, polishing, sanding or routing.

Cold flow—Change of dimensions or distortion caused by sustained application of a force greater than the elastic limit. Cold flow is generally low with thermoset products but is often appreciable and serious with thermoplastics. A high softening point generally reduces cold flow but at the same time makes molding more difficult.

Cold molding—A procedure in which a composition is shaped at ordinary temperatures and hardened by subsequent baking. Practiced particularly with asphalt-drying oil compositions containing asbestos filler to yield articles of high heat resistance.

Colloid—Any substance when dispersed into particles whose size ranges between 5 and 100 millimicrons. Molecules of many synthetic resins fall within this range.

Compressive strength—Resistance to deformation under applied pressure.

Condensation—A chemical reaction in which two or more molecules combine with separation of water or some other simple substance. Applied to synthetic resins it means the formation of a resin by combination of a number of molecules with elimination of water, ammonia, hydrogen chloride or other simple substance. Examples of condensation resins are alkyd, phenol-aldehyde and urea-formaldehyde resins. The final products are also called condensation-polymers. *See Polymerization.*

Co-polymerization—The term applied when two or more substances polymerize at the same time to yield a product which is not a mixture of separate polymers but a complex having properties different from either polymer alone. For example, Vinylite is produced by polymerization of a mixture of vinyl acetate and vinyl chloride.

C-Stage resins—Thermosetting resins in the final stage in which they are infusible and insoluble. The state of the resin in the final molded article.

Curing—The change of a binder from the soluble-fusible condition to the substantially insoluble-infusible form by chemical action. The heat-setting of a resinoid. Action is analogous to vulcanization of rubber.

Densification—Any procedure applied to a molding powder to lower its bulk factor.

Dielectric strength—Voltage gradient at which a continuous electrical discharge will take place between two electrodes when the material in question is placed between the electrodes and a potential difference is applied to them.

Elastic—A substance which exhibits rubber-like properties or "high elasticity" over a wide range of applied forces.

Elastic deformation—When a substance reverts to its original dimensions on release of an applied stress.

Elastic limit—The point at which a body begins to yield under a stress; that is, when the stress is equal to or greater than the internal friction.

Elasticity—The property by virtue of which a body reverts to its normal bulk or shape after deformation by an applied force.

Eucolloids—Linear polymers of a degree of polymerization over 1000; that is, each molecule is made up of over 1000 units of a simple substance. They show pronounced swelling and their solutions are highly viscous. The solid eucolloids are very tough and hard.

Extrusion molding—A molding procedure for extended shapes of uniform cross-section, whereby a heat-softened substance is forced through an orifice of form coinciding with the cross-section of the article.

Filled-products—Molding compositions or molded products containing fillers.

Flash mold—A mold designed to permit excess molding material to escape during final closing.

Flexibility—Capability of bending without breaking.

Flexural strength—Resistance of a substance to bending.

Fluidity—Reciprocal of the viscosity.

Gel—A somewhat rigid, generally transparent, two-

phase liquid-solid system in which the solid is precipitated as aggregates in and around which the liquid is held.

Gelation—Formation of a gel.

Gums—Viscous vegetable secretions which harden but, unlike resins, are water-soluble. The name is often applied, particularly in the varnish industry, to natural resins such as copals.

Hardness—Property of substances determined by their ability to abrade or indent one another. Often measured by the extent or depth of indentation produced by a standard substance under a predetermined load.

Hemicolloids—Polymers of molecular weight up to 10,000, corresponding to an order of polymerization equal to 20 to 100 monometric units. They dissolve without swelling and give solutions of low viscosity. Precipitation from solution yields powdery masses.

Hot molding—The process of converting a composition into an article of desired size and shape by heat and pressure.

Impact strength—The measure of toughness of a material. Generally determined by the energy required to break a specimen in one blow.

Injection molding—A molding procedure whereby a heat-softened plastic material is forced from a receptacle into a cavity which gives the article of desired shape. Used particularly for thermoplastics since the scrap can be re-used. As soon as the composition in the mold cools sufficiently to be rigid, the mold is opened and the molded article removed. An analogy of injection molding in another field is shown by the linotype machine.

Inserts—Parts of a finished molded article which are of different material from the molding composition but are set in place or positioned by the molding operation.

Jelly—A material of soft homogeneous consistency usually transparent and quivering when shaken. *See Gel.*

Laminated products—Sheets of material united by a binder. For example, sheets of paper or wood coated and/or impregnated with a resinous composition and subjected to pressure, generally with heat.

Lastic—A substance which at a certain temperature exhibits the physical properties of rubber. Unlike a viscous liquid, stress causes deformation at this temperature but removal of stress results in substantial recovery of the original shape.

Linear molecule—A molecule of highly elongated form. Generally applied to straight-chain polymers.

Loss factor—The product of the power factor and the dielectric constant.

Macromolecule—A molecule of such size that it exhibits colloidal properties.

Mesocolloids—Polymers intermediate between hemicolloids and eucolloids; that is, of a degree of polymerization between about 100 and 1000.

Modulus of elasticity—The stress required to produce a unit distortion.

Monomer—The simplest repeating structural unit of a polymer. For addition polymers this represents the originally unpolymerized compound.

Natural resins—Solid substances from vegetable excretions exhibiting brittleness, vitreous luster, conchoidal fracture, water-insolubility and varying fusibility and solubility.

Novolak—A permanently fusible and soluble phenol-aldehyde resin. More specifically it is the reaction-product of 1 molecule of phenol with less than 1 molecule of formaldehyde, and an acid catalyst.

Organic glass—A light-colored, transparent synthetic resin or resinous composition designed to simulate or surpass silicate glass in different respects, the ideal resin being expected to exhibit great toughness, light weight, high surface and scratch hardness, low water absorption and solubility, high softening and decomposition points, easy manipulation, and high stability under such conditions as weathering, light, chemical reagents and mechanical shock.

Phenoplast—A general term for phenol-aldehyde resins. Synonymous with popular term "phenolics."

Pitch—A dark-colored, fusible, more or less viscous to solid bituminous or resinous substance, insoluble in water but more or less soluble in carbon disulfide, benzol, etc. Composition and origin variable.

Plastic flow—When the flow is proportional to the pressure in excess of a certain minimum pressure (yield value) necessary to start the flow.

Plastics—All substances that can be molded. In general a plastic is a substance which behaves as a solid at stresses less than a certain amount known as the yield value and as a viscous liquid at stresses greater than this. The name is also applied to substances which originally but not ultimately fulfill this condition. For example, it is applied to thermoset compositions or resinoids in the final stages.

Plasticity—Susceptibility to and the retention of deformation. Capacity of taking and retaining the form of a mold. The property of solids by virtue of which they hold their shape permanently under the action of small shearing stresses but are readily deformed, worked or molded under larger stresses.

Polymerization—A chemical change resulting in the formation of a new compound whose molecular weight is a multiple of that of the original substance. The products of the reaction are called polymers. To distinguish from those resulting from condensation (q.v.), they are often designated addition polymers since the reaction is that of successive addition of a large number of relatively small molecules (monomers) to form the final polymer.

Positive mold—A mold designed to trap all the molding material to prevent its escape when it closes.

Potentially hardening—A term applied to resinoids, that is, to synthetic resins capable of passing into a C-stage.

Power factor—In an insulating material, the ratio of total power loss (watts) in the material to the product of voltage and current in a capacitor in which that material is a dielectric.

Preforms—Molding powders converted by pressure and without heat into a denser coherent form which approximates the shape of the final hot-pressed article. Molding

material converted to preforms has about half the bulk factor of the original powder. Other forms of densified composition, not necessarily the shape of the final molding, are tablets, briquettes, pellets, pills and balls.

Resin—A term generally referring to a physical condition at room temperature approximating the physical properties of natural resins (q.v.). However, the temperature of reference should not be limited to room temperature and the term is here intended to embrace all substances which within a certain temperature range show these properties. For example, many oil-modified alkyd resins are viscous liquids at room temperature but not at lower temperatures; polystyrene is a resin at room temperature but rubber-like when warmed.

Resinoids—The class name applied to thermosetting resins. Temporary thermoplastics. The name is also often applied to the final cured resins.

Resite—A phenol-aldehyde resin in the C-stage (q.v.).

Resitol—A name often applied to a phenol-aldehyde resin in the B-stage (q.v.).

Resol—A name often applied to a potentially hardening phenol-aldehyde resin in the A-stage (q.v.).

Softening point—Resins have no sharp melting point. Application of heat causes gradual change from a brittle or exceedingly thick and slow flowing material to a softer and less viscous liquid. The softening point is the temperature at which the material flows at a definite rate or to a definite distance.

Sol—A colloidal dispersion whose particles have sufficient Brownian motion to keep them in suspension.

Synlastic—A synthetic lastic (q.v.). Examples are Thiokol and Neoprene. Another name suggested for substances of this type is collastic.

Synthetic resin—A complex, substantially amorphous, organic semi-solid or solid material (usually a mixture of substances) built up by chemical reaction of comparatively simple compounds and, depending upon the temperature at which the examination is made, approximating the natural resins in various physical properties: namely, luster, fracture, comparative brittleness, insolubility in water, fusibility or plasticity when heated or exposed to heat and pressure, and, at a certain more or less narrow temperature range before fusion, showing a degree of rubber-like extensibility; but commonly deviating widely from natural resins in chemical constitution and behavior with reagents.

Synthetic rubber—Caoutchouc synthesized in the laboratory. The term is a misnomer and most probably represents an impossibility.

Tars—Dark-colored substances, liquid or semi-liquid at room temperature often possessing a characteristic "tarry" odor, usually insoluble in water but soluble in carbon disulfide, benzol, etc., and which on distillation, oxidation, etc., form a pitch. Composition variable.

Tensile strength—The sustained force required to break a piece of unit cross-section.

Thermoplastic—The property of softening under heat. All molding materials are thermoplastic at the initial application of heat. One class (the so-called thermoplastics) remains soft permanently under heat; the other (thermosetting), after first softening, sets or cures more or less quickly to a more solid form. A practical distinction is that with the first class the mold must be cooled before the molded article is removed, but not with the second. A thermoplastic substance is adequately rigid at normal temperatures and under ordinary conditions of stress but is capable of deformation under heat and pressure.

Thermosetting—The property of undergoing a chemical change when heated whereby a hardened product is obtained. Property most pronounced in phenol- and urea-formaldehyde resins and less so with alkyds. A thermosetting substance possesses initially the properties of a thermoplastic but under the influence of heat undergoes chemical change so that it is no longer thermoplastic but becomes permanently infusible.

Thixotropy—The property by which certain compositions become solid when at rest but liquefy again on agitation.

Transfer molding—Another name for injection molding (q.v.).

Treacle stage—A thermosetting neat resin in liquid form. Particularly applied to casting.

Urea resins—Thermosetting light-colored resins from urea and formaldehyde.

Vinyl resin—Thermoplastic derivatives of polyvinyl alcohol. Examples are Vinylite and Mowilith.

Viscosity—Internal friction or resistance to change of form of a liquid. The constant ratio of shearing stress to rate of shear.

Water-Absorption—Amount of water taken up when exposed to humid conditions or when immersed. Both rate of absorption and total absorption are important, also change in dimensions. A certain amount of absorbed water may improve mechanical properties but usually weakens electrical characteristics.

Yield value—The lowest pressure at which a plastic will flow. Below this pressure the plastic behaves as an elastic solid; above this pressure as a viscous liquid.

DIRECTORY OF CHEMICALS AND RAW MATERIALS

USED IN THE MANUFACTURE OF PLASTIC COMPOSITIONS UTILIZED IN THE PRODUCTION OF MOLDED OR FABRICATED PARTS

ACETIC ANHYDRIDE
American-British Chemical Supplies, Inc.
Carbide & Carbon Chemicals Corp.
Dow Chemical Co.
Mallinckrodt Chemical Works
Tennessee Eastman Corp.

ACETONE
Carbide & Carbon Chemicals Corp.
Cliff Dow Chemical Co.
Commercial Solvents Corp.
du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Co.
Kessler Chemical Corp.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Wishnick-Tumpeer, Inc.

ACETYLENE TETRACHLORIDE
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Innis, Speiden & Co., Inc.
U. S. Industrial Chemical Co.

ACID, ABIETIC
Glyco Products Co., Inc.
Hercules Powder Company
National Oil Products Co.

ACID, ACETIC
American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Cliff Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Co.
Mallinckrodt Chemical Works
Monsanto Chemical Co.
Penn Salt Mfg. Co.
Reilly Tar & Chemical Corp.
Shawinigan Products Corp.
Tennessee Eastman Corp.
Wishnick-Tumpeer, Inc.

ACID, BUTYRIC
Carbide & Carbon Chemicals Corp.
du Pont de Nemours & Co., Inc., E. I.
Innis, Speiden & Co., Inc.
Merck & Co., Inc.

ACID, CRESYLIC
American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Barrett Company
du Pont de Nemours & Co., Inc., E. I.
Koppers Co., Tar & Chemical Div.
Mallinckrodt Chemical Works
Monsanto Chemical Co.
Reilly Tar & Chemical Corp.

ACID, NITRIC
American Cyanamid & Chemical Corp.
du Pont de Nemours & Co., Inc., E. I.
General Chemical Co.
Hercules Powder Company
Mallinckrodt Chemical Works
Merck & Co., Inc.
Monsanto Chemical Co.

ACID, SEBACIC
National Aniline & Chemical Company, Inc.
National Oil Products Co.
Resinous Products & Chemical Co., Inc.

ACID, SUCCINIC
National Aniline & Chemical Co., Inc.

ACID, SULPHURIC
American Cyanamid & Chemical Corp.
Atlas Powder Company
du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Company
Mallinckrodt Chemical Works
Merck & Co., Inc.
Monsanto Chemical Co.
U. S. Rubber Products, Inc., Naugatuck Chemical Division

ALCOHOL-AMYL
Commercial Solvents Corp.
du Pont de Nemours & Co., Inc., E. I.
Kessler Chemical Corp.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Monsanto Chemical Co.
Sharples Solvents Corp.
U. S. Industrial Chemical Co.

ALCOHOL-BENZYL
American-British Chemical Supplies, Inc.
du Pont de Nemours & Co., Inc., E. I.
Kay-Fries Chemicals, Inc.
Merck & Co., Inc.
Monsanto Chemical Co.

ALCOHOL-BUTYL
Carbide & Carbon Chemicals Corp.
Commercial Solvents Corp.
Doe & Ingalls, Inc.
du Pont de Nemours & Co., Inc., E. I.
Kessler Chemical Corp.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Monsanto Chemical Co.
U. S. Industrial Chemical Co.

ALCOHOL, DIACETONE
Carbide & Carbon Chemicals Corp.
Commercial Solvents Corp.
Monsanto Chemical Co.

ALCOHOL-ETHYL
American Cyanamid & Chemical Corp.
Carbide & Carbon Chemicals Corp.
Commercial Solvents Corp.
du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Co.
McKesson & Robbins
Monsanto Chemical Co., Merrimac Div.
New England Alcohol Co.
U. S. Industrial Alcohol Co.
U. S. Industrial Chemical Co.

ALCOHOL-METHYL
Carbide & Carbon Chemicals Corp.
Cliff Dow Chemical Co.
Commercial Solvents Corp.
du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Co.
Mallinckrodt Chemical Works
Merck & Co., Inc.
National Oil & Supply Co.
Tennessee Eastman Corp.
U. S. Industrial Chemical Co., Inc.

ALDEHYDE AMMONIA
du Pont de Nemours & Co., Inc., E. I.

AMYL ACETATE
Commercial Solvents Corp.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Monsanto Chemical Co.
Sharples Solvents Corp.
U. S. Industrial Chemical Co.

ANILINE DYES
American Aniline Products, Inc.
Calco Chemical Company, Inc.
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
General Dyestuff Corporation
National Aniline & Chemical Co.
U. S. Rubber Products, Inc., Naugatuck Chemical Division

BENZYL BENZOATE
American-British Chemical Supplies, Inc.
du Pont de Nemours & Co., Inc., E. I.
Kay-Fries Chemicals, Inc.

BUTYL ACETATE
American-British Chemical Supplies, Inc.
Carbide & Carbon Chemicals Corp.
Commercial Solvents Corp.
du Pont de Nemours & Co., Inc., E. I.
Kessler Chemical Corp.
Monsanto Chemical Co.
U. S. Industrial Chemical Co.

CAMPHOR
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Mallinckrodt Chemical Works

CARBON BISULFIDE
American Cyanamid & Chemical Corp.
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Harshaw Chemical Co.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Wishnick-Tumpeer, Inc.

CARBON TETRACHLORIDE
American Cyanamid & Chemical Corp.
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Warner Chemical Co.
Wisnick-Tumpeer, Inc.

Addresses of the companies listed appear on pages 299-302, this section

CASEIN

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
American Plastics Corp.
Harshaw Chemical Co.
Hercules Powder Co.
Innis, Speiden & Co., Inc.
Merck & Co., Inc.

CASEIN

(Rods-Sheets-Tubes)

American Plastics Corp.

CELLULOSE ACETATE

(Rods-Sheets-Tubes)

American-British Chemical Supplies, Inc.
Celluloid Corp.
Cinelin Company
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Masury & Son, John W.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works

CELLULOSE ACETATE (Flake)

du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Co.
Tennessee Eastman Corp.

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MODEL MAKERS

Abel, Frank J.
Kunst Co., The, John
Stricker-Brunhuber Corp.

MOLDERS, COLD

American Insulator Corp.
Colt's Patent Fire Arms Mfg. Co.
Cutler-Hammer, Inc.
Garfield Mfg. Co.
General Electric Co., Plastics Dept.
Haveg Corp.

Addresses of companies listed appear on pages 299-302, this section

MOLDERS' MARKINGS

Accurate Molding Co., Brooklyn, N. Y.

AMCO

Accurate Molding Co., Brooklyn, N. Y.

QUALITY ARPCO PRODUCTS

The Ackerman Rubber & Plastic Molding Company, Cleveland, Ohio

Advance Molding Corp., New York, N. Y.

NA-ALD

Alden Products Corp., Brockton, Mass.

ACE

American Hard Rubber Co., Butler, N. J.

American Insulator Corp., New Freedom, Pa.

Anchor Cap & Closure Corporation, Long Island City, New York

Armstrong Cork Products Company, Lancaster, Pa.

The Arrow-Hart & Hegeman Electric Co., Hartford, Conn.

Associated Attleboro Mfrs., Inc., Attleboro, Mass.

Auburn Button Works, Auburn, N. Y.

Bay Manufacturing Company Division of Electric Auto-Lite Company, Bay City, Michigan

Belmont Plastics Incorporated, Cincinnati, Ohio

Berkalin QUALITY JEWELRY MADE IN U.S.A.

Geo. F. Berkander, Providence, R. I.

Boonton Molding Co., Boonton, N. J.

Bridgeport Molded Products, Inc., Bridgeport, Conn.

Bryant Electric Co., Bridgeport, Conn.

CHICAGO MOLDED PROD. CORP.

Chicago Molded Products Corp., Chicago, Ill.

Cincinnati Molding Co., Cincinnati, Ohio

COLT

Colt's Patent Fire Arms Co., Hartford, Conn.

Consolidated Molded Products Corp., Scranton, Pa.

C-H

Cutler-Hammer, Inc., Milwaukee, Wisconsin

Cruver Manufacturing Co., Inc., Chicago, Ill.

DALMO

Dalmo Manufacturing Co., San Francisco, Calif.

DAKA-WARE

Harry Davies Molding Co., Chicago, Ill.

Dayton Insulating Molding Co., Dayton, Ohio

Diemolding Corp., Canastota, N. Y.

Eclipse Moulded Products Company, Milwaukee, Wis.

MOLDERS' MARKINGS

The Emeloid Co., Inc., Arlington, N. J.

Erie Resistor Corp., Erie, Pa.

Firestone Tire & Rubber Company, Akron, Ohio

Garfield Mfg. Co., Garfield, N. J.

General Electric Co., Pittsfield, Mass.

General Industries, Inc., Elyria, Ohio

General Molding Co., Rockledge, Pa.

Gits Molding Corporation, Chicago, Ill.

Gorham Company, Providence, R. I.

The Grigoleit Co., Decatur, Ill.

Wm. Gulliksen Machinery Co., Newton Lower Falls, Mass.

Harry W. Hahn Mfg. Co., Los Angeles, Calif.

Imperial Molded Products Co., Chicago, Ill.

Industrial Molded Products Co., Chicago, Ill.

Insulation Manufacturing Co., Inc., Brooklyn, N. Y.

Insulation Manufacturing Co., Inc., Brooklyn, N. Y.

International Molded Plastics, Inc., Cleveland, Ohio

Keasbey & Mattison Co., Ambler, Pa.

Kellogg Switchboard and Supply Co., Chicago, Ill.

Kuhn and Jacob Moulding & Tool Co., Trenton, N. J.

Kurz-Kasch, Inc., Dayton, Ohio

Mack Molding Co., Inc., Wayne, N. J.

McDonald Mfg. Co., Los Angeles, Calif.

Mico, Inc., Millerton, N. Y.

Midwest Molding & Mfg. Co., Chicago, Ill.

Elmer E. Mills Corporation, Chicago, Ill.

Modern Plastics Corp., Kokomo, Ind.

Molded Insulation Co., Philadelphia, Pa.

Molding Corp. of America, Providence, R. I.

National Lock Co. Rockford, Ill.

National Plastics, Inc., Knoxville, Tenn.

Northern Industrial Chemical Co., S. Boston, Mass.

Bell Mfg. Co., Division of Northern Industrial Chemical Co., S. Boston, Mass.

Norton Laboratories, Lockport, N. Y.

Oris Mfg. Co., Thomaston, Conn.

MOLDERS' MARKINGS

Owens-Illinois Glass Company, Toledo, Ohio

The Panelyte Corp., New York, N. Y.

Peerless Molded Plastics, Inc., Toledo, Ohio

Plastic Molding Corp., Cincinnati, Ohio

Plastic Molding Corporation, Sandy Hook, Conn.

Recto Molded Products Co., Cincinnati, O.

Reynolds Molded Plastics Division of Reynolds Spring Co., Jackson, Michigan

Reynolds Spring Co., Jackson, Mich.

Reynolds Spring Co., Jackson, Mich.

The Richardson Co., Melrose Park, Chicago, Ill.

Royal Molding Co., Providence, R. I.

Shaw Insulator Co., Irvington, N. J.

Shaw Insulator Co., Irvington, N. J.

Specialty Insulation Mfg. Co., Inc., Hoosick Falls, N. Y.

Standard Cap & Molding Co., Baltimore, Md.

Jos. Stokes Rubber Co., Trenton, N. J.

Synthetic Moulded Products, Inc., Stonington, Conn.

Tech-Art Plastics Co., Long Island City, N. Y.

Terkelsen Machine Co. Boston, Mass.

The Thomas Mason Co., Inc., Stamford, Conn.

Union Insulating Co., Parkersburg, W. Va.

Universal Molding Co., San Francisco, Calif.

Universal Plastics Corp., New Brunswick, N. J.

Waterbury Button Co., Waterbury, Conn.

Watertown Mfg. Co., Watertown, Conn.

Westinghouse Elec. & Mfg. Co., Trafford, Pa.

Wheeling Stamping Co., Wheeling, W. Va.

Windman Brothers, Los Angeles, California

DIRECTORY OF TRADE NAMES

AND MANUFACTURERS OF PLASTICS LISTED IN PROPERTIES CHART

Phenol-Formaldehyde Molding Compounds

Bakelite	Bakelite Corp., 247 Park Ave., New York
Catalin	Catalin Corp., 1 Park Ave., New York
Celeron	Continental Diamond Fibre Co., Newark, Del. N. Y. office: 230 Park Ave.
Durez	General Plastics Inc., 710 E. Walck Rd., N. Tonawanda, N. Y. N. Y. office: 250 Park Ave.
Durite	Durite Plastics, 5010 Summerdale Ave. (near Roosevelt B'lvd.), Philadelphia, Pa.
Heresite	Heresite and Chemical Co., 822 S. 14th St., Manitowoc, Wis.
Indur	Reilly Tar & Chemical Corp., 500 Fifth Ave., New York, N. Y.
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Makalot	Makalot Corp., 262 Washington St., Boston, Mass.
Resinox	Resinox Corp., 17 Battery Pl., New York
Textolite	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Uniplast	Universal Plastics Co., 235 Jersey Ave., New Brunswick, N. J.

Phenol-Formaldehyde Laminated Products

Aqualite	National Vulcanized Fibre Co., Wilmington, Del.
Celeron	Continental Diamond Fibre Co., Newark Del. N. Y. office: 230 Park Ave.
Dilecto	Do.
Dilophane	Do.
Duraloy	Detroit Paper Products Corp., 5800 Domine St., Detroit, Mich.
Fibroc	Continental Diamond Fibre Co , Newark, Del.
Formica	Formica Insulation Co., 4672 Spring Grove Ave., Cincinnati, Ohio N. Y. office: 101 Park Ave.
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Lamicoid	Mica Insulator Co., 200 Varick St., New York, N. Y.
Micarta	Westinghouse Electric & Mfg. Co., Micarta Div., Trafford, Pa.
Ohmoid	Wilmington Fibre Specialty Co., East Wilmington, Del.
Panelyte	Panelyte Corp., 230 Park Ave., New York,
Phenolite	National Vulcanized Fibre Co., Wilmington, Del.
Spauldite	Spaulding Fibre Co., 313 Wheeler St., Tonawanda, N. Y. N. Y. office: 484 Broome St.
Synthane	Synthane Corp., Oaks, Pa.
Taylor	Taylor Fibre Co., Norristown, Pa. N. Y. office: 90 West St.
Textolite	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Ucinite	United-Carr Fastener Corp., 31 Ames St., Cambridge, Mass.

Phenol-Formaldehyde Cast Resins

Bakelite	Bakelite Corp., 247 Park Ave., New York
Catalin	Catalin Corp., 1 Park Ave., New York
Fiberlon	Plastics Div., Monsanto Chemical Co , Indian Orchard, Mass. N. Y. office: 60 E. 42nd St.
Marblette	Marblette Corp., 37–21 30th St., Long Island City, N. Y.

Phenol-Furfural Resins

Durite	Durite Plastics, 5010 Summerdale Ave. (near Roosevelt B'lvd.), Philadelphia, Pa.

Urea-Formaldehyde Molding Compounds

Bakelite	Bakelite Corp., 247 Park Ave., New York
Beetle	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York
Plaskon	Plaskon Co., Inc., 2112 Sylvan Ave., Toledo, Ohio N. Y. office: 41 E. 42nd St.
Unyte	Do.

Urea-Formaldehyde Laminated Products

Beetle	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York
Formica	Formica Insulation Co., 4671 Spring Grove Ave., Cincinnati, Ohio
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill.
Micarta	Westinghouse Electric & Mfg. Co., Micarta Div., Trafford, Pa.

Vinyl Resins

Alvar	Shawinigan Products Corp., 350 Fifth Ave. New York, N. Y.
Butvar.	Do.
Formvar	Do.
Gelva	Do.
Solvar	Do.
Vinylite	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York, N. Y.
———	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.

Acrylate and Methacrylate Resins

Crystalite	(Molding compound)	Röhm & Haas Co., Inc. 222 W. Washington Square, Philadelphia
Lucite	(Molding compound & cast resin)	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.
Plexiglas	(Cast resin)	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia

Styrene Resins

Bakelite	Bakelite Corp., 247 Park Ave., New York
Styron	Dow Chemical Co.. Midland, Mich.

Shellac Compounds

Compo-Site	Compo-Site, Inc., 207 Astor St., Newark, N. J.
Harvite	Siemon Co., Bridgeport, Conn. N. Y. office: 145 Varick St.
Lacanite	Consolidated Molded Products Corp., 1938 Modern St., Scranton, Pa. N. Y. office: 1776 B'way.
———	T. F. Butterfield, Inc., 58 Rubber St., Naugatuck, Conn. N. Y. office: 303 Fifth Ave.
———	Waterbury Button Co., Waterbury, Conn. N. Y. office: 1133 B'way.

Cold Molded—Bituminous Type (Non-Refractory)

Aico	American Insulator Corp., New Freedom, Pa. N. Y. office: 101 Park Ave.
Amerine (phenolic)	Do.
Cetec-Non-Refractory	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Ebrok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Gummon	Garfield Mfg. Co., Wallington Rd., Garfield, N. J.
Oken	American Hard Rubber Co , 11 Mercer St., New York
Stoco	Joseph Stokes Rubber Co., 322 Webster St., Trenton, N. J.
Thermoplax	Cutler-Hammer, Inc., 1333 W.St. Paul Ave., Milwaukee, Wis. N. Y. office: 8 W. 40th St.

Cold Molded—Ceramic Type (Refractory)

Aico –5	American Insulator Corp., New Freedom Pa.
Alphide	Standard Plastics Corp., 106 B'way, Jersey City, N. J.
Cetec-Refractory	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Coltstone	Colt's Patent Fire Arms Mfg. Co., 1935 Van Dyke Ave., Hartford, Conn. N. Y. office: 20 Vesey St.
Hemit	Garfield Mfg. Co., Wallington Rd., Garfield, N. J.
Pyroplax	Cutler-Hammer, Inc., 1333 W.St. Paul Ave., Milwaukee, Wis. N. Y. office: 8 W. 40th St.

Rubber Derivatives and Rubber-like Resins

Amerlite	Aqueous dispersion	American Anode, Inc., Akron, Ohio
Corprene	Synthetic rubber with ground cork	Armstrong Cork Products Co., Liberty St., Lancaster, Pa.
Flamenol	Vinyl chloride resin	General Electric Co., 1 River Rd., Schenectady, N. Y.
Kogene	Synthetic elastic	B. F. Goodrich Co., 454 S. Main St., Akron, Ohio
Koroseal	Vinyl chloride resin	Do.
Marbo	Chlorinated rubber	Marbo Products Corp., 469 E. Ohio St., Chicago, Ill.
Marbon	Do.	Do.
Neoprene	Chloroprene	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del. N. Y. office: 350 Fifth Ave.
Pliofilm	Rubber hydrochloride	Goodyear Tire & Rubber Co., Inc., 1400 Cartwright St., Akron, Ohio N. Y. office: 600 W. 58th St.
Plioform	Modified isomerized rubber	Do.
Pliolite	Do.	Do.
Thiokol	Olefin polysulfide	Thiokol Corp., 780 N. Clinton Ave., Trenton, N. J.
Tornesit	Chlorinated rubber	Hercules Powder Co., 999 Market St., Wilmington, Del. N. Y. office: 20 E. 40th St.

Hard Rubber

Ace	American Hard Rubber Co., 11 Mercer St., New York, N. Y.
Luzerne	Luzerne Rubber Co., Dewey St., Trenton, N. J.
Rub-tex	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
———	Joseph Stokes Rubber Co., 322 Webster St., Trenton, N. J.
———	Vulcanized Rubber Co., 2 E. 29th St., New York, N. Y.

Casein

Aladdinite	Aladdinite Corp., 261 Wallace St., Orange, N. J.
Ameroid	American Plastics Corp., 50 Union Square, New York, N. Y.

Ethylcellulose

Ethocel	Dow Chemical Co., 919 Jefferson Ave., Midland, Mich.
———	Hercules Powder Co., 999 Market St., Wilmington, Del. N. Y. office: 20 E. 40th St.

Cellulose Acetate

Bakelite	Bakelite Corp., 247 Park Ave., New York
Fibestos	Plastics Div., Monsanto Chemical Co., Indian Orchard, Mass. N. Y. office: 60 E. 42nd St.
Lumarith	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Masuron	John W. Masury & Son, 50 Jay St., Brooklyn N. Y.
Nixonite	Nixon Nitration Works, Nixon, N. J.
Plastacele	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.
Tenite	Tennessee Eastman Corp., Kingsport, Tenn. N. Y. office: Room 4105, 10 E. 40th St.
———	Hercules Powder Co., 999 Market St., Wilmington, Del.

Cellulose Nitrate (Pyroxylin)

Celluloid	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Fiberloid	Plastics Div., Monsanto Chemical Co., Indian Orchard, Mass. N. Y. office: 60 E. 42nd St.
Nixonoid	Nixon Nitration Works, Nixon, N. J.
Pyralin	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.

Coumarone-Indene Resins

Cumar	Barrett Co., 40 Rector St., New York, N. Y.
Neville Resin	Neville Co., Neville Island Post Office, Pittsburgh, Pa.
Nevindene	Do.

Lignin Plastics

Benaloid	Uncured lignin sheets	Masonite Corp., Laurel, Miss.
Benalite	Cured lignin sheets	Do.

Varnish and Lacquer Resins

Trade Name	Composition	Manufacturer
Abalyn	Methyl abietate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Acryloid	Acrylic	Resinous Products & Chemical Co., Inc., 222 W. Washington Square, Philadelphia
Acrysol	Do.	Do.
Aero Ester Gum	Rosin-glycerol	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Akco	Phenolic	Do.
Amberlac	Alkyd	Resinous Products & Chemical Co., Inc., 222 W. Washington Square, Philadelphia
Amberlite	Laminating phenolic	Do.
Amberol	Phenolic	Do.
Aquaplex	Alkyd emulsion	Do.
Aroclor	Chlorinated diphenyl	Monsanto Chemical Co., 1700 S. 2nd St., St. Louis, Mo.
Bakelite	Phenolic	Bakelite Corp., 247 Park Ave., New York
Beckacite	Modified phenolic	Reichhold Chemicals, Inc. 601 Woodward Hts. Blvd., Detroit, Mich.
Beckamine	Urea-formaldehyde	Do.
Beckolin	Synthetic oil	Do.
Beckosol	Do.	Do.
Beckopol	Phenolated copal	Do.
Beetle	Urea-formaldehyde	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Dulux	Alkyd	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.
Dura	Phenolic	Paramet Chemical Corp., 1017 Forty-fourth Ave., Long Island City, N. Y.
Duraplex	Alkyd	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Durez	Phenolic	General Plastics Inc., N. Tonawanda, N. Y.
Esterol	Alkyd	Paramet Chemical Corp., 1017 Forty-fourth Ave., Long Island City, N. Y.
G	Glycerol-phthalic anhydride	Makalot Corp., 262 Washington St., Boston, Mass.
Glyptal	Alkyd	General Electric Co., Bridgeport, Conn.
Hercolyn	Hydrogenated methyl abietate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Imperial Ester	Rosin-glycerol	J. D. Lewis, Inc., 68 Traverse St., Providence, R. I.
Kopol	Esterified copals	Reichhold Chemicals, Inc. 601 Woodward Hts. Blvd., Detroit, Mich.
Lewisol	Alkyd and phenolic	J. D. Lewis, Inc., 68 Traverse St., Providence, R. I.
Makalot	Alkyd, phenolic, and urea-formaldehyde	Makalot Corp., 262 Washington St., Boston, Mass.
Paradura	Phenolic	Paramet Chemical Corp., 1017 Forty-fourth Ave., Long Island City, N. Y.
Paramet Ester Gum	Rosin-glycerol	Do.
Paranol	Phenolic	Do.
Paraplex	Alkyd	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Petrex	Terpinene maleic anhydride	Hercules Powder Co., 999 Market St., Wilmington, Del.
Phenac	Phenolic	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Rauzene	Phenolic	U. S. Industrial Alcohol Co., 480 Frelinghuysen Ave., Newark, N. J.
Rauzene Ester	Rosin-glyceride	Do.
Rauzite	Urea-formaldehyde	Do.
Rauzone	Alkyd	Do.
Rezyl	Alkyd	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Santolite	Toluene sulfonamid formaldehyde	Monsanto Chemical Co., 1700 S. 2nd St., St. Louis, Mo.
Staybelite	Hydrogenated rosin	Hercules Powder Co. 999 Market St., Wilmington, Del.
Super-Beckacite	Pure phenolic	Reichhold Chemicals, Inc. 601 Woodward Hts. Blvd., Detroit, Mich.
Syntho-Copal	Rosin-glycerol	Do.
Teglac	Alkyd	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Uformite	Laminating urea-formaldehyde resin	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Vinsol	Modified rosin	Hercules Powder Co., 999 Market St., Wilmington, Del.
Vinylite	Vinyl resin	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York

Miscellaneous Plastics

Abopon	Boro-phosphate	Glyco Products Co., Inc., 148 Lafayette St., N. Y.
Acwalite	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Adheso Wax	Synthetic wax	Glyco Products Co., Inc., 148 Lafayette St., N. Y.
Ameray	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Amer-glo	Do.	Do.
Amerith	Do.	Do.
Aquaresin	Glycol boriborate	Glyco Products Co. Inc., 148 Lafayette St., N. Y.
Arcolite	Phenolic	Consolidated Molded Products Corp., 1938 Modern St., Scranton Pa.
Art-Y-Zan	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Beetleware	Urea moldings	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Bonnyware	Urea moldings	Reynolds Molded Plastics, Div., Reynolds Spring Co., Jackson, Mich.
Cellanite	Phenolic laminated	Continental Diamond Fibre Co., Newark, Del.
Celerit	Moulage reinforcing mass (positive)	Kern Co., 136 Liberty St., New York
Celeron	Phenolic impregnated fabric	Continental Diamond Fibre Co., Newark, Del.
Cellophane	Regenerated cellulose wrapping	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.
Cellulak	Shellac paper-laminated tubing	Continental Diamond Fibre Co., Newark, Del.
Ceraflux	Synthetic wax	Glyco Products Co., Inc., 148 Lafayette St., N. Y.
Charmour	Cellulose acetate	Celluloid Corp., 10 E. 40th St., New York
Cibanite	Aniline resin	Ciba Co., Inc., 627 Greenwich St., N. Y.
Cibanoid	Urea-formaldehyde resin	Do.
Clair de Lune	Cellulose acetate	Celluloid Corp., 10 E. 40th St., New York
Colasta	Phenolic, etc.	Specialty Insulation Mfg. Co., 55 Center Ave., Hoosick Falls, N. Y.
Coltrock	Phenolic	Colt's Patent Fire Arms Mfg. Co., 1935 Van Dyke Ave., Hartford, Conn.
Etholoil	Ethylcellulose foil	Dow Chemical Co., Midland, Mich.
Fiberlac	Cellulose nitrate lacquer	Plastics Div., Monsanto Chem. Co., Indian Orchard, Mass.
Flexoresin	Glycol and glyceryl phthalates	Glyco Products Co., 148 Lafayette St., New York
Flexowax	Synthetic wax	Do.
Gemloid	Pyroxylin and cellulose acetate	Gemloid Corp., 425 Fourth Ave., New York, N. Y.
Glycene	Alkyd denture	Bakelite Corp., 247 Park Ave., New York
H-Scale	Synthetic pearl essence	Celluloid Corp., 10 E. 40th St., New York.
Halowax	Chlorinated naphthalenes	Halowax Corp., 247 Park Ave., New York
Harvel	Cashew nut derivative	Irvington Varnish & Insulator Co., Irvington, N. J.
Haskelite	Plywood bonded with phenolic resin	Haskelite Mfg. Co., 208 W. Washington St., Chicago, Ill.
Haveg	Phenolic-asbestos	Haveg Corp., E. Newark, Del.
Hemcoware	Urea moldings	Bryant Electric Co., 1934 Weaver Ave., Bridgeport, Conn.
Hercose AP	Cellulose acetopropionate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Hercose C	Cellulose acetate butyrate	Do.
Herculoid	Cellulose nitrate	Do.
Hominit	Moulage (positive mass)	Kern Co., 136 Liberty St., New York, N. Y.
Hydroresin A	Water soluble resin	Glyco Products Co. 148 Lafayette St., New York
Ivaleur	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Kodaloid	Cellulose nitrate	Eastman Kodak Co., Rochester, N. Y.
Kodapak	Cellulose acetate	Do.
Lauxite	Urea-formaldehyde-zinc chloride, resin for plywood	I. F. Laucks, Inc., 116 S Niagara St., Lockport N. Y.
Lumarith Protectoid	Cellulose acetate packaging material	Celluloid Corp., 10 E. 40th St., New York
Luxene	Phenolic denture	Bakelite Corp., 247 Park Ave., New York
Malzite	Alcohol soluble protein	Prolamine Products, Inc., 100 E. 42nd St., New York
Melocol	Polyamide formaldehyde	Ciba Co., Inc., 627 Greenwich St., New York
Melopas	Do.	Do.
Micabond	Bonded mica	Continental Diamond Fibre Co., Newark, Del.
Micanite	Mica	Mica Insulator Co., 200 Varick St., New York
Micoid	Phenolic laminated	Do.
Negocoll	Moulage (negative mass)	Kern Co., 136 Liberty St., New York, N. Y.
Nevillac	Phenol-Indene coumarone	Neville Co., Neville Island Post Office, Pittsburgh, Pa.
Nevillite	Hydrocarbon	Do.
Norbo	Phenolic resin	Bakelite Corp., 247 Park Ave., New York
Plastico	Moulage (negative mass)	California Art Supply Co., Inc., Palo Alto, Cal. Eastern representative: Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa.
Plexigum	Acrylic resin for laminated glass	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia
Posmoulage	Moulage (positive mass)	California Art Supply Co., Inc., Palo Alto, Cal.
Primal	Acrylic resin for leather finishes	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia.
Protecto	Cellulose acetate box toe material	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Proxyl	Pyroxylin denture	Lee S. Smith & Son Mfg. Co., 7325 Pa. Ave., Pittsburgh, Pa.
Prystal	Cast phenolic (clear)	Catalin Corp., 1 Park Ave., New York
Resisto	Pyroxylin box toe material	Celluloid Corp., 10 E. 40th St., New York
Resovin	Vinyl denture	S. S. White Dental Mfg. Co., 211 S. 12th St., Philadelphia, Pa.
Resowax	Synthetic wax	Glyco Products Co., 148 Lafayette St., New York
Revolite	Cloth impregnated with phenolic resin	Zapon Div., Atlas Powder Co., Stamford Conn.
Reziwood	Phenolic laminated wood	I. F. Laucks Inc., Maritime Bldg., Seattle, Wash.
Rheolan	Thermoplastic pitch-like solid	Glyco Products Co., 148 Lafayette St., New York
RHonite	Urea resin	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia
RHoplex	Acrylic resin for textile finishes	Do.
Ronyx	Corn protein plastic	Resinox Corp., 230 Park Ave., New York
Safety Samson	Cellulose acetate film base	Celluloid Corp., 10 E. 40th St., New York
Samson	Pyroxylin film base	Do.
Sundera	Cellulose acetate	E. I. du Pont de Nemours & Co. Inc., Plastics Dept., 626 Schuyle Ave., Arlington, N. J.
Sylphwrap	Regenerated cellulose wrapping	Sylvania Industrial Corp., 122 E. 42nd St., New York, N. Y.
Tec	Cellulose acetate	Tennessee Eastman Corp., Kingsport, Tenn.
Tego	Phenolic resin for plywood	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Templus	Phenolic molding composition	Bryant Electric Co., 1934 Weaver Ave., Bridgeport, Conn.
Vinal	Vinyl acetal resin for safety glass	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York
Vinylite X	Do.	Do.
Vinylseal	Vinyl resin sealing compound	Do.
Vistanex	Hydrocarbon resin	Advance Solvents & Chemical Corp., 245 Fifth Ave., New York
Vulcoid	Phenolic laminated vulcanized fibre	Continental Diamond Fibre Co., Newark, Del.
Wadec	Colored plastic clay	California Art Supply Co., Inc., Palo Alto Cal.

ALPHABETICAL INDEX OF ALL MANUFACTURERS AND ADDRESSES

Advertisers are listed in bold-face type and the numerals immediately following addresses indicate the page numbers on which their advertisements appear. For further information, refer to advertising pages or write advertisers direct

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ALPHABETICAL LIST OF ALL

Advertisers in this issue are listed in bold-face type; numerals indicate advertising pages

Commonwealth Plastics Co., 39 Spruce St., Leominster, Mass.—169
Compo-site, Inc., 207 Astor St., Newark, N. J.
Composition Materials Co., Inc., 25 W. 43 St., New York, N. Y.
Consolidated Ashcroft Hancock Co., 1033 Kossuth St., Bridgeport, Conn.
Consolidated Molded Products Corp., 1935 Case St., Scranton, Pa.
Continental Carbon Co., 295 Madison Ave., New York, N. Y.
Continental-Diamond Fibre Co., E. Newark, Del.
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